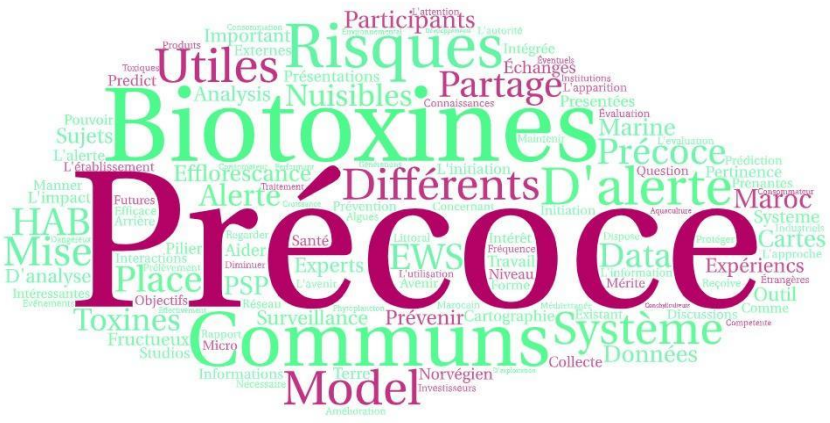
# STAKEHOLDER NEEDS ASSESSMENT FOR ESTABLISHING AN EARLY WARNING SYSTEM FOR HARMFUL ALGAL BLOOMS IN MOROCCO

**Workshop 5th - 8th December 2022, Casablanca, Morocco**



## Executive Summary

Forty-five invited stakeholder participants attended a four day workshop, 'Stakeholders needs assessment for establishing an Early Warning System (EWS) for Harmful Algal Blooms (HABs) in Morocco' on 5th – 8th December 2022 in Casablanca, Morocco.

This workshop was sponsored by UNESCO/IOC and hosted by L'Institut National de Recherche Halieutique, INRH, Casablanca, Morocco.

Morocco was the second country to receive support for developing and establishing an EWS within the framework of this project funded by Government of Norway (NORAD). The 'Technical Guidance document for the implementation of EWS for Harmful Algal Blooms', recently developed jointly by FAO-IOC-IAEA, was used to provide the background and as guidelines to these discussions to foster engagement through a step by step process.

The first thematic area was the identification and assessment of stakeholders needs and requirements, current capacity, pre-existing and missing knowledge and data gaps and what the current limiting factors and resources in establishing an Early Warning System (EWS) in Moroccan coastal waters. Follow-on discussions were held on the practical elements and issues in relation to meeting and fulfilling the requirements of acquiring laboratory accreditation to ISO standards, particularly with method validation in the areas of biotoxin and phytoplankton analysis.

The second focused thematic area concentrated on the formatting and standardisation of data from in-situ monitoring programmes (marine biotoxin concentrations in shellfish and phytoplankton species abundance in water) to be used in evaluating historical data, reassessing currently used phytoplankton thresholds and to be used more easily in predictive forecasting models to ascertain the probability of the onset of HAB event occurring within a region.

We have identified critical follow-up actions steps by reviewing the stakeholders activities and their expectations for an EWS, detailed in the Recommendations section of this report.

## Project Background

Based on the cooperation agreement between UNESCO and Norwegian Agency for Development Cooperation (NORAD), the project led by UNESCO's Intergovernmental Oceanographic Commission (IOC) in partnership with FAO and IAEA will address issues related to Harmful Algal Blooms (HAB), which have significant impacts on food safety and nutrition, through contamination of fish and shellfish, or massive kills of marine organisms. Considering their severe impacts, it is desirable to implement a HAB early warning system (EWS) to help mitigate the impact of HABs. Recognizing that the combination of new knowledge and technology is making HAB early warning and forecasting more feasible than previously, the IOC Intergovernmental

Panel on Harmful Algal Blooms (IPHAB) set up a task team to work on the guidelines for EWS for HAB. In 2019, this Task Team and their plans for guidelines for EWS for HAB and capability to partner in the implementation in a number of pilot projects to develop and test tailored EWS systems form a solid basis for the implementation of this project. The development and testing of EWS for HAB will serve to meet local/national requirements of seafood safety regulations and the main goals are to protect public health, reduce economic disruptions and minimize associated economic losses on fisheries due to HABs.

## Objective

The objective of this workshop was to assess stakeholder needs and train national counterparts on national monitoring data management, visualization and predictive forecast modeling to initiate the development of an EWS in Morocco for HAB events.

## Work Conducted

The workshop was held on 5$^{th}$ – 8$^{th}$ December 2022 in Idou Anfa Hotel, Casablanca, and opened by Mr Samir Benbrahim, INRH, and Mr Mohamed Alaoui, Chef de la section des Sciences Exactes et Naturelles Bureau de l'UNESCO pour le Maghreb.

The meeting was conducted in both French and English, with the support of professional translators during the first 2 days.

The workshop was broadly comprised of a two day stakeholder engagement workshop on EWS for HABs, followed by a two day Data workshop, which focused on predictive modelling systems which could be implemented for operational use in Morocco for the prediction of the onset and duration of HAB events, specifically predicting Paralytic Shellfish Toxin (PST) events in shellfish species of live bi-valve molluscs.

Forty-five participants (Fig. 1.) from government ministries, private sector, academic institutions and official laboratories, including two representatives from UNESCO Maghreb region, participated in the workshop.

The agenda of the four-day workshop, including titles of presentations given, is detailed. Copies of the presentations have been made available to all participants through sharing and access through a Google drive folder.

*Fig. 1. Group photo of stakeholder and expert group participants.*

Sessions consisted of a series of presentations (by both stakeholder participants and the Expert group), interactive discussions, surveys and polls. These were led by an Expert Group Panel, invited and established by UNESCO/IOC. These experts participated in the development of the Technical Guidance document.

Prior to the workshop, a questionnaire was submitted to participants to establish a background and starting point for the Expert Group and to design the agenda for the workshop. In total, 25 submissions were returned, providing detailed information on their experiences with HAB events and their expectations of an EWS for HABs.

Follow-on discussions were held on the practical elements and issues in relation to meeting and fulfilling the requirements of acquiring laboratory accreditation to ISO 17025 standards, particularly with method validation.

Sharing information and knowledge amongst stakeholders about HABs and EWS was conducted through a series of presentations by experts and Moroccan counterparts. A considerable amount of time was set aside to facilitate open discussion amongst all stakeholders and the expert group panel in reviewing current and future stakeholder structure and engagement.

The Klaxoon Board! Application (https://klaxoon.com/)[1] was used to capture inputs from the participating stakeholders (responses in French) and to facilitate discussion in a number of key thematic areas, including:

- Identification of relevant stakeholders.
- Identification of the HAB problem, thereby identifying the effects and consequences.
- Review of ongoing monitoring activity as a basis which could support the foundation and development of a HAB EWS system.
- Stakeholders identified gaps, not only in knowledge, but also in capacity, for example instrumentation and full accessibility of data.
- The expectations around envisaging the formation of a specific Alert Bulletin in Moroccan coastal waters.

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[1] Klaxoon provides access to a full suite of collaborative tools (whiteboard, survey, quiz, live polling, etc.) designed to boost teamwork efficiency.

Stakeholder discussion

Below are screenshots of the responses (in French) captured by Klaxoon, followed by a summary of the responses to each question or topic.

**Identification of relevant stakeholders**

Eleven institutions including governmental agencies, laboratories and the industry participated in the workshop. Most of the stakeholders attending were from INRH, with representatives from the different regional centers along the Mediterranean and the Atlantic coast (Nador, Tangier, Casablanca, Agadir, Laayoune and Dakhla. Fig. 2.)


*Fig. 2. The six INRH regional centers involved in HAB monitoring.*

## Identification of relevant stakeholders

This session identified all the relevant stakeholders invested in an EWS, facilitated through interactive discussion with the stakeholders who were present (Fig. 3.). It was identified that industry, such as aquaculture producers and commercial tourism businesses, including those associated with the seafood sector, should have a larger input in the process. In addition the academic Institutes, media, the Ministry of the Interior and the Chambres des Pêches Maritimes, should be involved in the collation of inputs into the process mechanism.

| Autres parties prenantes identifiées | Parties prenantes participant à l'atelier |
|---|---|
| professionnels aquaculture<br>Ministère de l'intérieur<br>Universités<br>Média<br>Restaurateurs produits de la mer<br>Scientifiques de l'INRH<br>secteur du tourisme<br>Chambre des pêches maritimes (atlantique nord, sud, centre et Med) | •INRH -Casablanca, Oujda, Tanger, Oaalidia, Laâyoune, Agadir, Dakhla<br>•Département de la Pêche Maritime (DPM), DIPM -Rabat<br>•Office National de Sécurité Sanitaire des Produits Alimentaires (ONSSA) -Rabat<br>•Laboratoire Nationale des Etudes et de la Surveillance de la Pollution (LNESP) -Rabat<br>•Agence nationale pour le développement de l'aquaculture (ANDA) -Rabat<br>•Direction de l'épidemiologie et de lutte contre les maladies (DELM) -Rabat<br>•Marine Royale –Casablanca<br>•Aqua M'diq –Tanger (poissons)<br>•Coastal Culture Systèmes (Azura) –Dakhla (palourde)<br>•Les Domaines Agricoles –Casablanca (aquaculture)<br>•Cumarex, Conserverie des produits de la mer -Tetouan |

*Fig. 3. Identification of relevant stakeholders.*

## Identifying HAB Problems and their consequences

Identifying the stakeholders requirements through harmful algae events and associated problems through a combination of knowledge and experience, and why these are a problem for stakeholders, particularly with regard to the consequential issues arising from HAB events.
This exercise was achieved through capturing interactive inputs by stakeholders.

**Types of HAB species and biotoxins detected**

Based on input and presentation from the participants, the main HAB problem (Fig. 4.) is the presence of pelagic toxin producing harmful phytoplanktonic species and toxin accumulation in shellfish. This included regulated toxins as well as emerging toxins, such as PLTX, gymnodimine, neurotoxins. HABs mentioned included high biomass blooms with mass mortalities, *Lingulodinium polyedra* with cysts, and the benthic species *Ostreopsis*. *Gambierdiscus* spp. was identified in the south of the Atlantic coast. For mortalities in fish aquaculture, it was suggested to consider analyzing biotoxin or phytoplankton as the causative origin of observed mortalities.

# Quel type de problème HAB le Maroc connaît-il ?

Toxines, Intoxications humaines

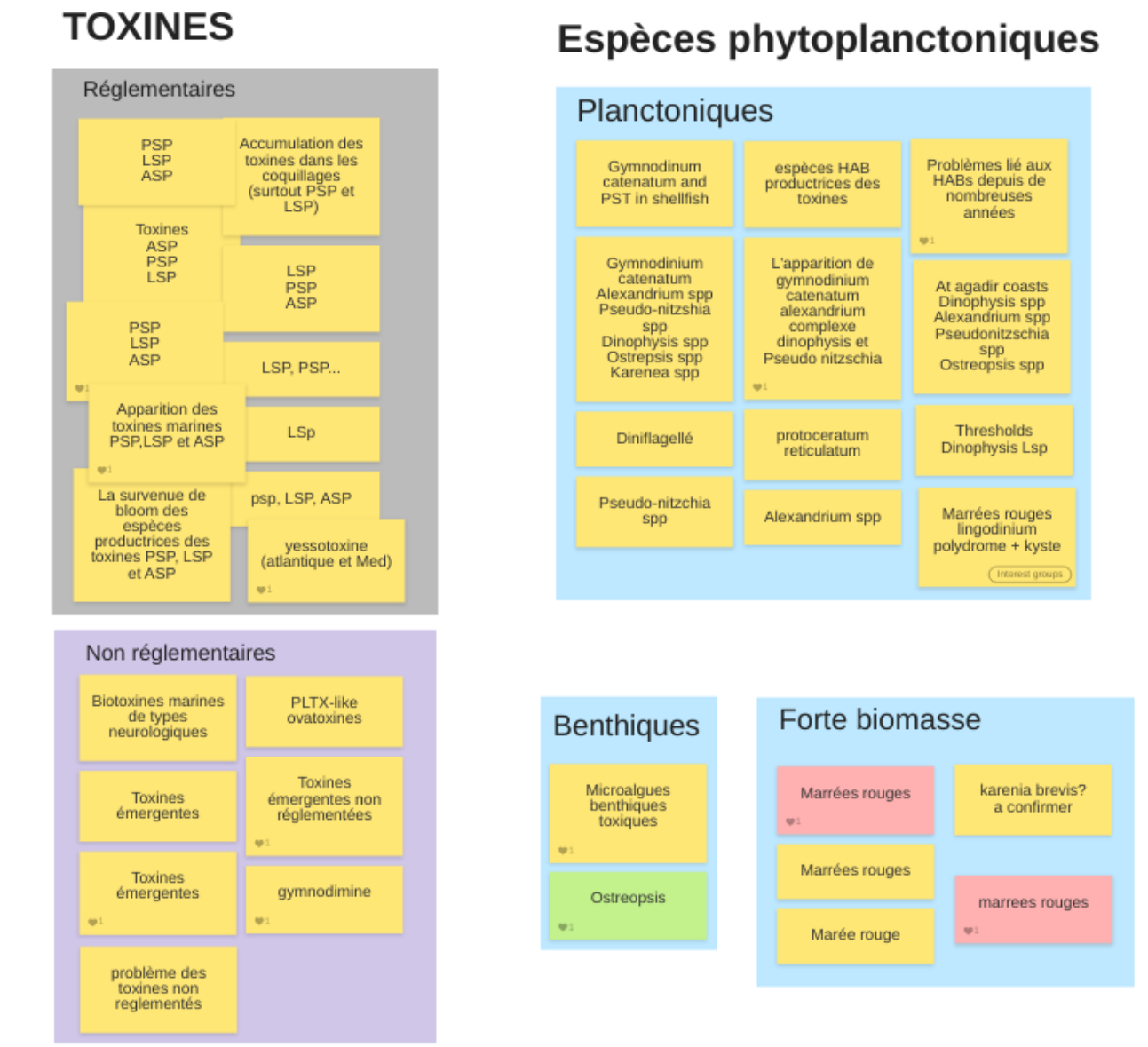


*Fig. 4. Types of HAB species and biotoxins detected.*

## Effects and Issues arising from HAB events

Participants identified numerous issues around HAB toxins (Fig. 5.), involving food intoxication (human illness associated with Diarrhetic Shellfish Toxins (DST) and also skin irritation) and additionally fatalities (prior to the establishment of a monitoring program in the 1990's) due to problems with Paralytic Shellfish Toxins (PST) and also human health issues observed in swimming areas that are not monitored for HABs.

Concerns about HAB effects were also reflected in many of the above observations, focusing on human illnesses (DST food intoxications, skin irritation) via seafood contamination above safety threshold levels, as well mentioning mass mortalities of marine species, including birds, fish (wild and aquaculture) and marine species in general. Repeated closures of aquaculture sites and shellfish trade bans prohibiting the harvesting and placing on the market for human consumption, were also mentioned by a large number of participants and some expressed concerns about preventative closures.

# Quels types de problèmes les événements HAB provoquent-ils ?
# Effets - Fermetures, Mortalités


*Fig. 5. Types of problems associated with HAB events.*

**Consequences arising from HAB events:**

The participants identified socioeconomic consequences directly on the industry through economical loss, on the communities through job losses, and through negative impacts on tourism. Socioeconomic consequences were also reflected in market considerations, with products no longer legally available and the development of illegal markets, reduction of seafood consumption and loss of trust in seafood products with a subsequent decrease in product demand (Fig. 6.). There were implications for regulatory management and decisions pertaining to product recall, harvest loss, or reimmersion of the products, as well as monitoring intensification.

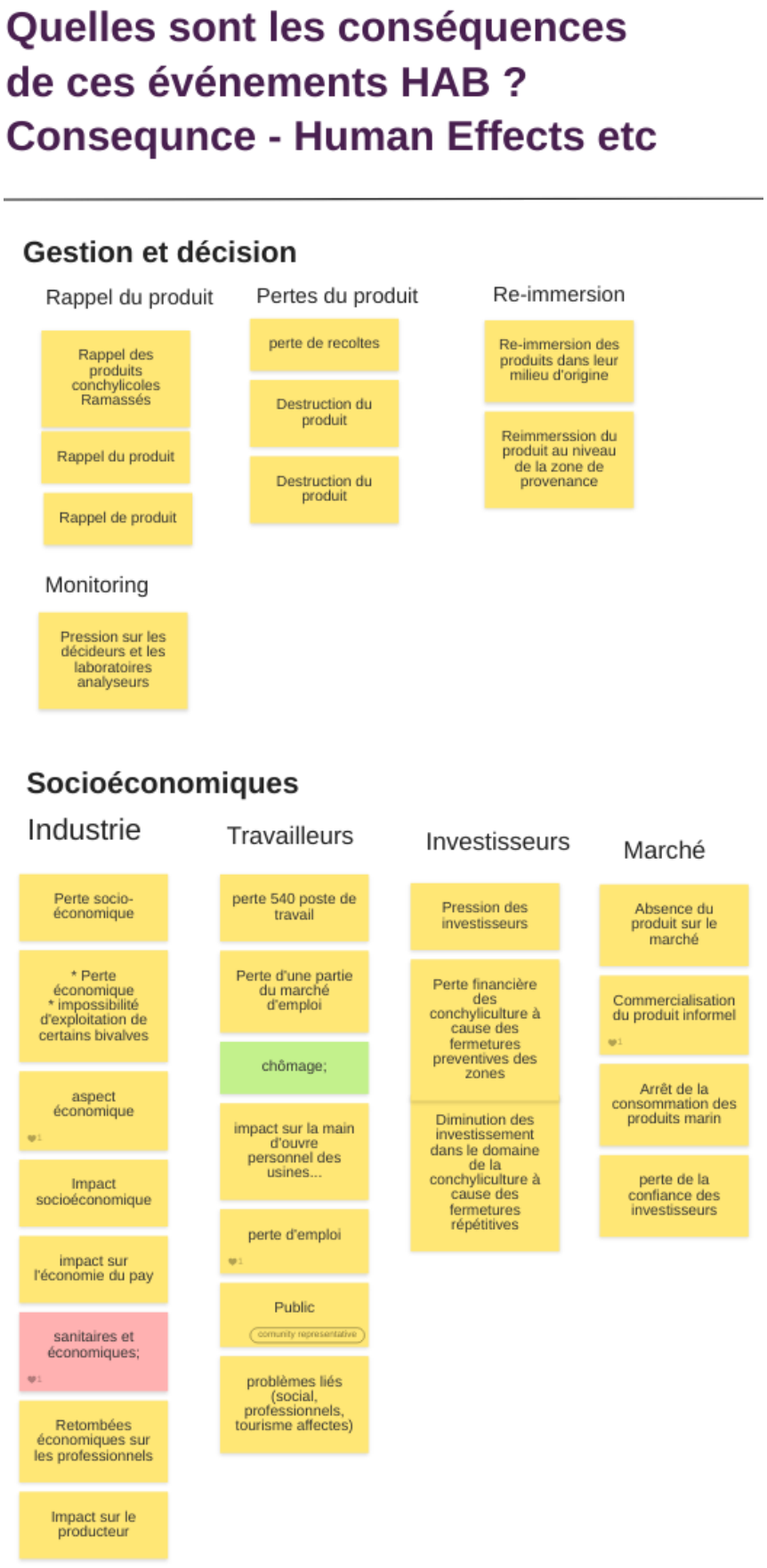


*Fig. 6. Consequences and issues arising from HAB events.*

Existing Capacity for EWS development

There is an existing monitoring program with data sources available for the development of an EWS in Morocco. Data includes the long term monitoring of cells and toxins collected by INRH, environmental data collected weekly at certain sites, and existing global data and model repositories that can be accessed for regional data through repositories like Copernicus (Fig. 7.).

Gaps, Obstacles, and Challenges in implementing an EWS

There are some gaps where capacity could be improved. These include the need for PST analytical processes, availability of certified reference material, the time required for toxin analysis is too long, and there is a need for further training on phytoplankton analysis and on analytical methods for biotoxins. There may also be the need to revise phytoplankton thresholds for pre-alert (Fig. 7.).

Issues regarding equipment included the limited locations that are equipped with toxin analysis tools. Samples from certain regions (Nador, in the north) need to be shipped to Casablanca for analysis. Microscopes should also be upgraded as only inverted microscopes are available.

In terms of operation, the time frame for toxin analysis was raised again. There were also challenges mentioned regarding importing toxin reference material, and data exchange between INRH and the industry.

In terms of data from long term HAB monitoring, these lack from certain areas along the coast. In addition to HAB data there is a general lack of systematic and long term physical and chemical data that could have been useful in the statistical analysis of HAB presence. Most of the data collected are from the inner coastline and data from the open ocean that could be important for interpretation of coast-open water processes is lacking. Based on the presentation and discussions the problem with lack of data is greatest on the Atlantic coastline due to difficulties in accessing and performance of water column sampling. Even though there was identified statistical knowledge in the stakeholder group, it was pointed out that human resources for developmenting, maintaining and running oceanographic models might be an obstacle in the further development of EWS. Investment in new instruments, analytic tools, as well maintenance was identified as a threat for the long run of a EWS.

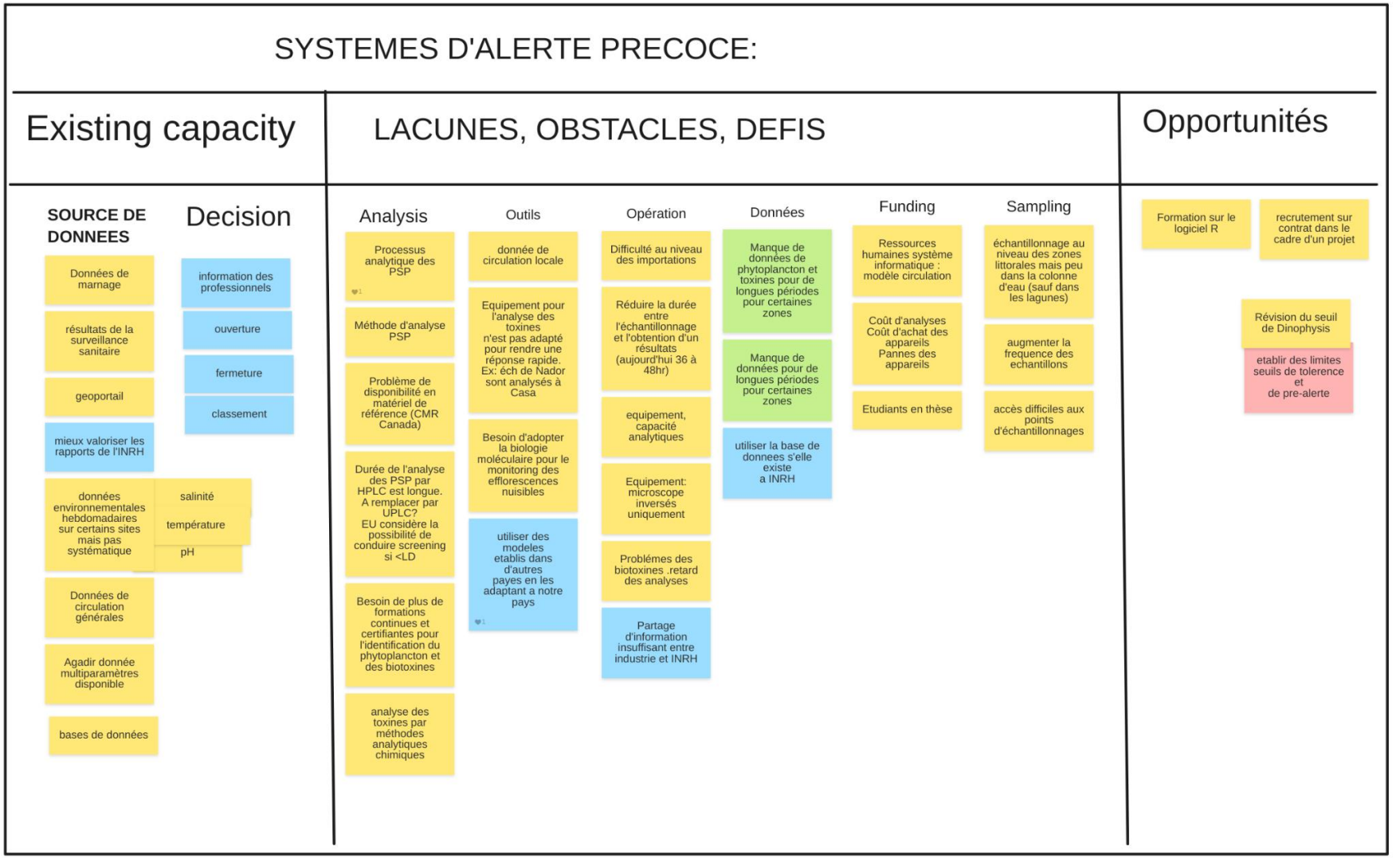


*Fig. 7. Existing capacity, difficulties, and opportunities with establishing an EWS in Morocco.*

EWS Bulletin -requirements, scoping and visualisation

An example of a weekly alert bulletin (Ireland) was presented to stakeholders so they could visualise how a similar report specific to Moroccan coastal waters may be realised, and what data sources, visualisation and their expectations from an alert bulletin. A lot of interest was expressed by stakeholders, with discussion of a way to automate the process of bulletin creation, similar to the Jupyter Notebook approach of the Ireland bulletin.

A prototype markdown bulletin file was created as an example to build from. This prototype was made available in the shared folder with the other R tutorials and materials from the data workshop.

Observations captured (Fig. 8.) during this discussion area include:

- The issue of the day of release was raised with a preference of a release on Friday with fisherman being off on Friday while the administration not working on Saturday and Sunday.
- The representative of the Investors and industry expressed the need to have access to more data such as environmental data as well as model data. Fish aquaculture, although not concerned by closure, would need to have information on phytoplankton that could lead to stress, behavioural changes or mortalities. However, a geoportal is under development with site, location, and information.
- The aquaculture industry would need to have a probability that would define a risk in time and space rather than the announcement of a closure. The monitoring should be optimized to the profit of the professional.
- Health ministry needs to have access to the surveillance data, including chemical, bacteriological and HABs.
- Shellfish producers need more access to data.

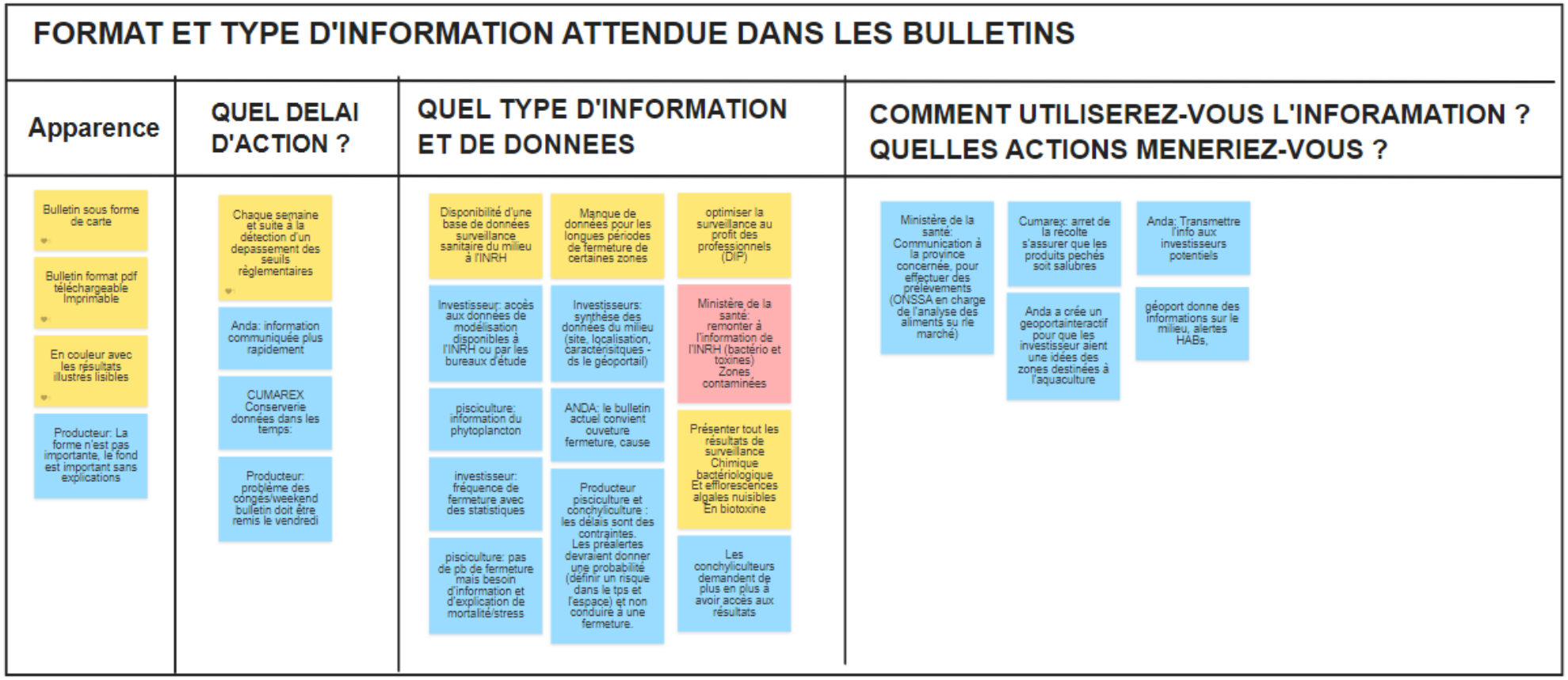


*Fig. 8. Information requirements for an EWS bulletin.*

There was not a large discussion around visualization. Although the visualization was not identified as important, a few participants expressed the need to have maps with clear, easy to understand legend, using color illustrating the problems. It should also be possible to download maps for further use. It was pointed out that the bulletin should be weekly or as soon as a threshold is exceeded.

A participant survey, on current monitoring conditions, was conducted, where the corresponding results (Fig. 9.) were circulated to participants at the end of the meeting.

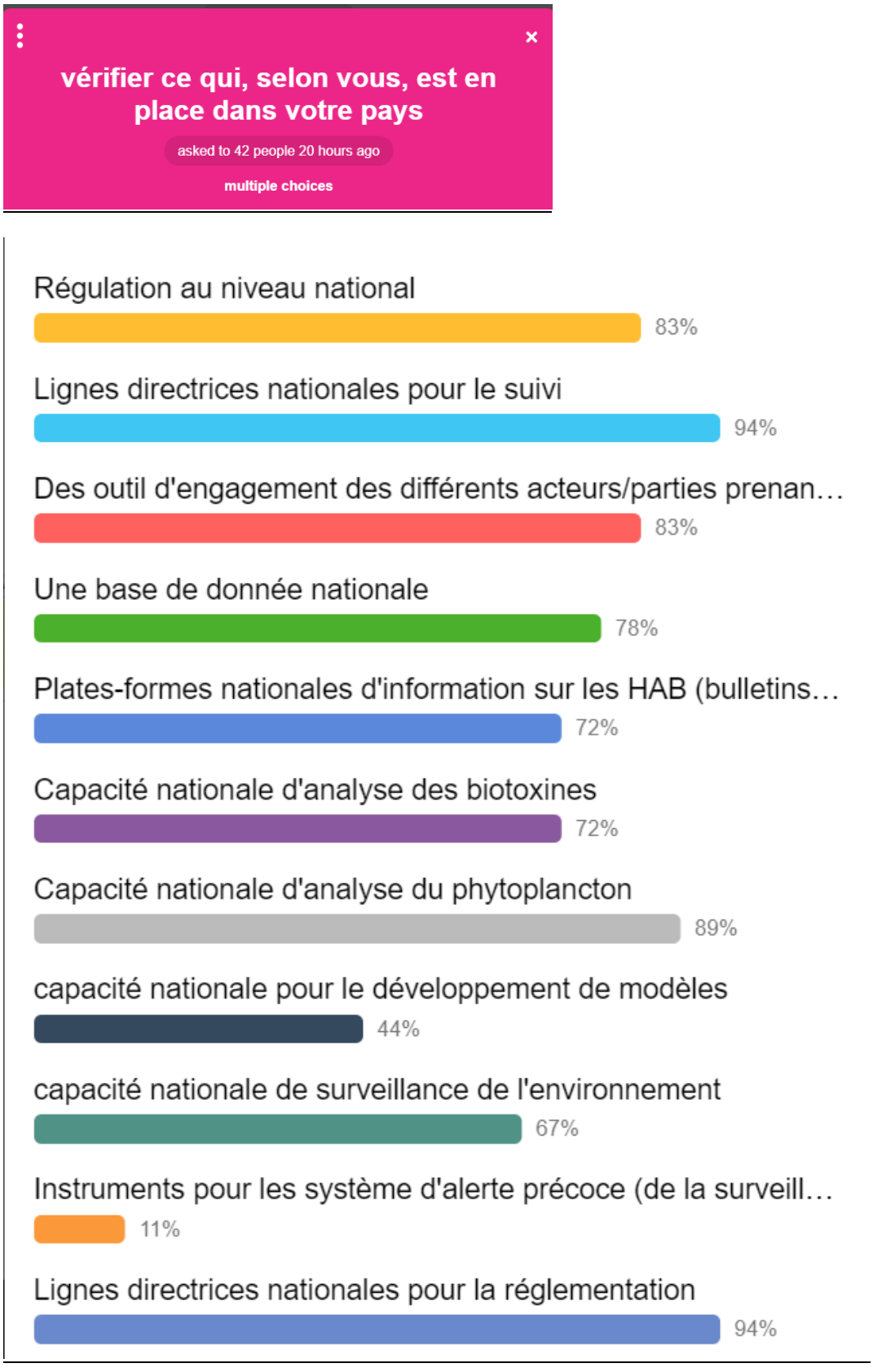


*Fig. 9. Participant survey - what is currently in place.*

The majority of the participants agreed that rules and guidelines are available with capacity available and in operation in Morocco to address HABs, and that there are tools to engage with stakeholders and a platform to communicate on HABs. Yet close to 60% consider that the capacity is insufficient for the development of Prediction models and 89% identified Instrument availability as insufficient in Morocco.

## Data Workshop

Three sessions were provided for data management, visualization and modeling primarily in the R programming environment. The sessions were (1) an introduction to programming provided to the full group of participants, (2) a session on modeling and machine learning provided to a smaller group of participants with some modeling experience, and (3) a session for standardization of data reporting and management. All materials presented (code, tutorials, example data formats etc) were shared with the participants for continued use along with some additional coding tools that there was not time to cover. The outcome of the data standards discussion was a template for compilation and sharing of data.

Needs were identified for progress in the area of data and modeling. A small group of participants was identified with the capacity and interest to continue in R programming and modeling (Mr Azeddine Ramzi, Mme Sarra Berguia, Mr Benlachen Rijal Leblad). Future work should include continued training for this group. Resources can be provided by the expert group. A data template was developed for clean and standardized data for which a data entry portal will be built in Access; the template should be used across monitoring programs.

## Conclusion

The workshop was extremely rich in discussion, participants were very open and communicative, demonstrating great knowledge, recognising the value of teamwork and collaboration, and were invested in having follow-up actions to this workshop. Involvement of the participants was beyond expectations, with additional requests for additional meeting time during and around the days of the workshop, notably to discuss approaches for internal validation of methods for phytoplankton and biotoxin analysis.

The interactive and flexible open format of the workshop greatly assisted in achieving the workshop objectives to identify stakeholder needs and provide the initial training on national monitoring data management, visualization and predictive forecast modeling for the development of an EWS in Morocco for HAB events.

The expertise offered by the panel of 6 experts proved to be extremely valuable, responding to the range and intensity of demands from the participants in terms of analysis in the areas of

phytoplankton, biotoxin and environmental monitoring, as well as in basic and advanced computational data analysis.

Specific outputs included:

- The preparation of a formatted spreadsheet to standardise data entry in the six different regional centers and facilitate future use as a direct data source in an early warning system. The representatives from the IT section offered to create a Microsoft Access database platform to facilitate the ease, and streamline data entry of in-situ datasets.
- A first set of needs was identified to guide the future development of the EWS, to identify some specific requirements from the stakeholders in terms of information to include in the bulletins, and from INRH stakeholders in terms of monitoring (i.e. following a science-based approach through historical data analysis, improving the effectiveness of the system in place, in particular assess the relevance of the threshold implemented).
- Participants were presented with the 'R' programming language tool and tutored to its use. Nationals with computational expertise were identified to undertake future work required in the development of a HAB EWS. Parallel advanced discussion on model development, with more expert participants provided the basis for follow-up data analysis.
- The participants left with a good understanding of the requirements in terms of data analysis towards both optimizing the monitoring strategy, in particular to revise the phytoplankton thresholds, and developing a EWS specific to the Moroccan region.
- A set of follow-up priority actions and inputs were identified for a much needed and hoped for follow-up project.

It is recognised that the Moroccan authorities have implemented and operate long term continuous national monitoring programmes in the areas of marine biotoxin concentration detection and quantification in live bi-valve molluscs, with phytoplankton identification and enumeration in classified production areas. The current monitoring is aligned with the requirements as laid down in EU legislation. Non-classified areas are prohibited for the recreational harvesting of shellfish.

**Recommendations**

The recommendation is to extend this project and associated activities with additional workshops (up to 3), the provision of small equipment items, and the provision of onsite technical experts to spend short periods of time in Moroccan institutions to assist data and laboratory analysts, and urge the UNESCO/IOC to consider this request.

1. Stakeholders identified gaps, not only in knowledge, but also in capacity, for example instrumentation (capacity) for biotoxin analysis, method validation and accreditation (knowledge) and data accessibility.
2. Realisation through further workshop and dedicated expert visits in HAB bulletin visualisation and datasets to drive predictive models, which support the continual evolution of development, implementation and maintenance of a HAB EWS system specific for the shellfish aquaculture industry and related stakeholders along the Moroccan coastline.
3. Additional involvement of industry stakeholders as end product users in future meetings for feedback and evaluation on HAB warning forecast bulletins and their usefulness as a mitigation strategy in risk management decision making.
4. Prepare publications for peer-reviewed literature.
5. Further development and implementation of in-situ (biotoxin and phytoplankton) data entry template/platform, this was initially developed during the meeting for historical data and future data entry, storage and extraction.
6. Conduct historical phytoplankton and shellfish contamination data analysis to assess relevance, based on scientific evidence, in re-evaluating currently used pre-alert phytoplankton thresholds
7. Training in data analysis and modelling for selected individuals in order to improve the ability to use Morocco's in-situ datasets and remote sensing in analysis and predictive modelling.
8. Technical support and guidance to INRH regional laboratories to assist with method validation in the areas of Paralytic Shellfish Toxin analysis by HPLC, Lipophilic Shellfish Toxin analysis by LC-MS/MS and Phytoplankton identification and enumeration by microscopy (Utermöhl method).

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Note for future workshop:

It would have assisted the experts to have been informed ahead of the workshop, an organogram with participants organized by role and institution, as well as an understanding of the role of each institution where name badges with affiliated institutions would have been very useful too.