Final Evaluation Report

Your Details	
Full Name	Ramiro de Jesús Arcos Aguilar
Project Title	Enhancing surveillance in the Gulf of California: uncovering ecological indicators driving illegal fishing
Application ID	41571-1
Date of this Report	April 2025

1. Indicate the level of achievement of the project's original objectives and include any relevant comments on factors affecting this.

Objective	Not achieved	Partially achieved	Fully achieved	Comments
a) One year of seasonal underwater surveys to fill the gaps of ecological information			x	A total of 18 stations were monitored across five regions in La Paz Bay during the four seasons of the year. These stations filled a gap in the information of the long-term monitoring program based on the PROMARES methodology of UABCS. Initially, 20 stations were sampled; however, two of the selected sites did not have a rocky reef habitat. At the beginning of the project, we planned to start during the winter of 2024, but we received the funds at the end of February, so we began in the spring and are set to finish in the winter of 2025. As an additional outcome, former fishers were integrated into the study, as the methodology used initially limited octopus observation. At each sampling station, PROMARES monitoring was conducted, and time-defined transects were carried out to implement a new methodology for octopus detection, which proved to be successful.
b) Data from surveillance activities of 2024			x	We integrated 167 surveillance trips to the activities we consider form February 2024 to February 2025
A report from the descriptive statistical analysis informing the ecological structure of the sites with historically detected		x		We have analysed the information separately so far. However, the relationship between biomass and illegal activities is still under evaluation and will be finalized in the

fishing activities.				coming months.
A workshop to discuss results and improve the tactics used for surveillance activities			x	We conducted workshops in various fishing communities to present and improve surveillance tactics. Currently, we are also still training four communities to professionalize their surveillance programs. At the same time, we are developing a community diagnosis to better understand the needs and opportunity areas of each community.
A scientific paper submitted to an indexed journal containing the analysis of the information collected in this project.		x		We were planning to submit the first paper at beginnings of 2025, however we are delayed on the submission time, we have to submit the paper before June 2025.

2. Describe the three most important outcomes of your project.

a) Underwater stational surveys

We successfully filled existing information gaps and established a comprehensive 2024 database of marine ecosystem descriptors by measuring key ecological variables, including biomass and species abundance, using the PROMARES - UABCS survey method. This database now includes detailed records of commercial fishing resources in areas where illegal fishing activities have been detected (Figure 1 and Figure 2, right). Additionally, we obtained a clear description of the size structure of underwater communities, capturing both the number and size of each species. This is particularly relevant as it reflects the living resources within the ecosystem.

Historical Underwater Rocky Reef Surveys	2024-2025 Rufford Proyect Surveys

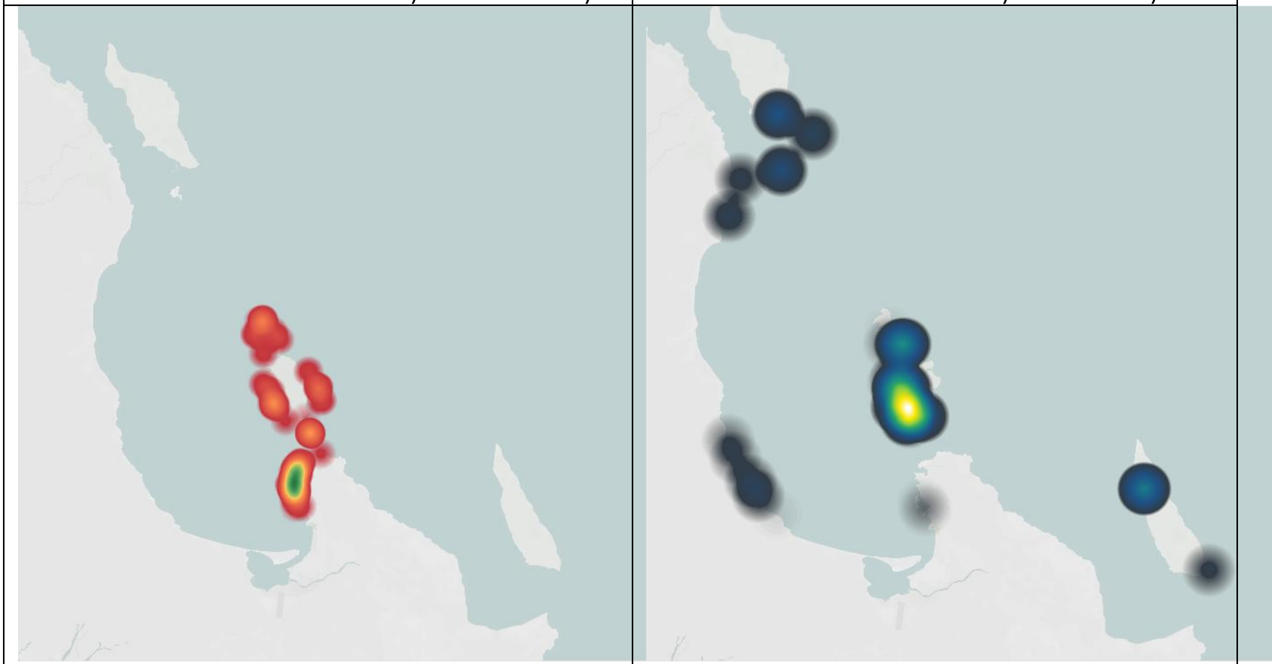

Figure 1. Heatmaps of underwater rocky reef survey efforts in La Paz Bay, Baja California Sur. The left panel shows historical survey locations, primarily concentrated in the southern portion of the bay. The right panel displays the expanded geographic coverage of the 2024–2025 Rufford Project surveys, indicating broader exploration across the bay.

Species richness for the present (i.e., number of species) of fish and invertebrates, categorized by commercial importance and surveyed across five regions within La Paz Bay: Corredor, San Juan de la Costa, PNZMAES (a marine protected area, MPA), La Ventana, and APFFB (another MPA).

Fish – Commercial Species:
Richness is highest in Corredor (19 species), followed by San Juan de la Costa (17), PNZMAES (16), La Ventana (13), and lowest in APFFB (8).

Fish – Non-Commercial Species:
All regions show higher richness in non-commercial species, with Corredor (45) again leading, followed by San Juan de la Costa (43), PNZMAES (42), La Ventana (39), and APFFB (20).

Invertebrates – Commercial Species:
Richness is low overall, with only 5 species recorded in Corredor, PNZMAES, and San Juan de la Costa, 4 in La Ventana, and just 2 in APFFB.

Invertebrates – Non-Commercial Species:
Corredor leads significantly (46 species), followed by PNZMAES (42), San Juan de la Costa (30), La Ventana (29), and APFFB (17).

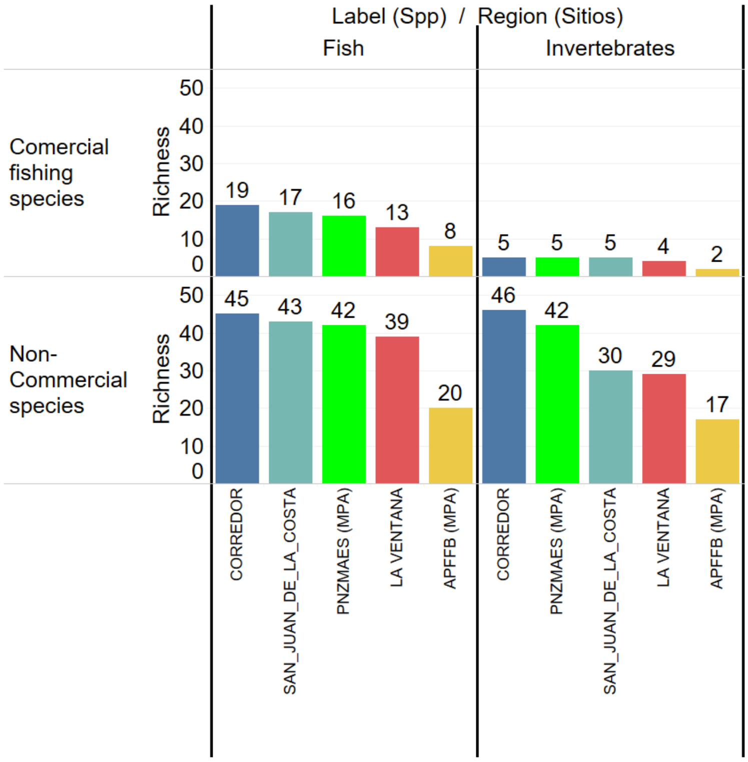

Figure 2. Species richness of fish and invertebrates across five regions in La Paz Bay, Baja California Sur, categorized by commercial importance.

The size frequency of relevant fishing resources shows the distribution of individual fish species across four seasons—Spring, Summer, Fall, and Winter. There is evidence that *Scarus* spp. (Scaridae) and *Mycteroperca rosacea* (Serranidae) are present year-round, but their size distributions vary between seasons, potentially reflecting growth or recruitment events. Some species, such as *Lutjanus argentiventris*, exhibit greater size variation or increased presence during Summer and Winter, suggesting seasonal habitat use or migration patterns. Notably, *Scarus* spp., although not a protected species, is a significant target for illegal fishing in the area. Despite its importance, it is not reported in official landing records for La Paz Bay (Figure 3).

It is important to note that these results are based only on seasonal sampling at selected sites during this project. Nevertheless, understanding recruitment events is crucial for future monitoring efforts. More exhaustive surveys focused on commercially important species such as *Lutjanus argentiventris* and *Mycteroperca rosacea* are recommended to better assess their population dynamics and inform sustainable management strategies.

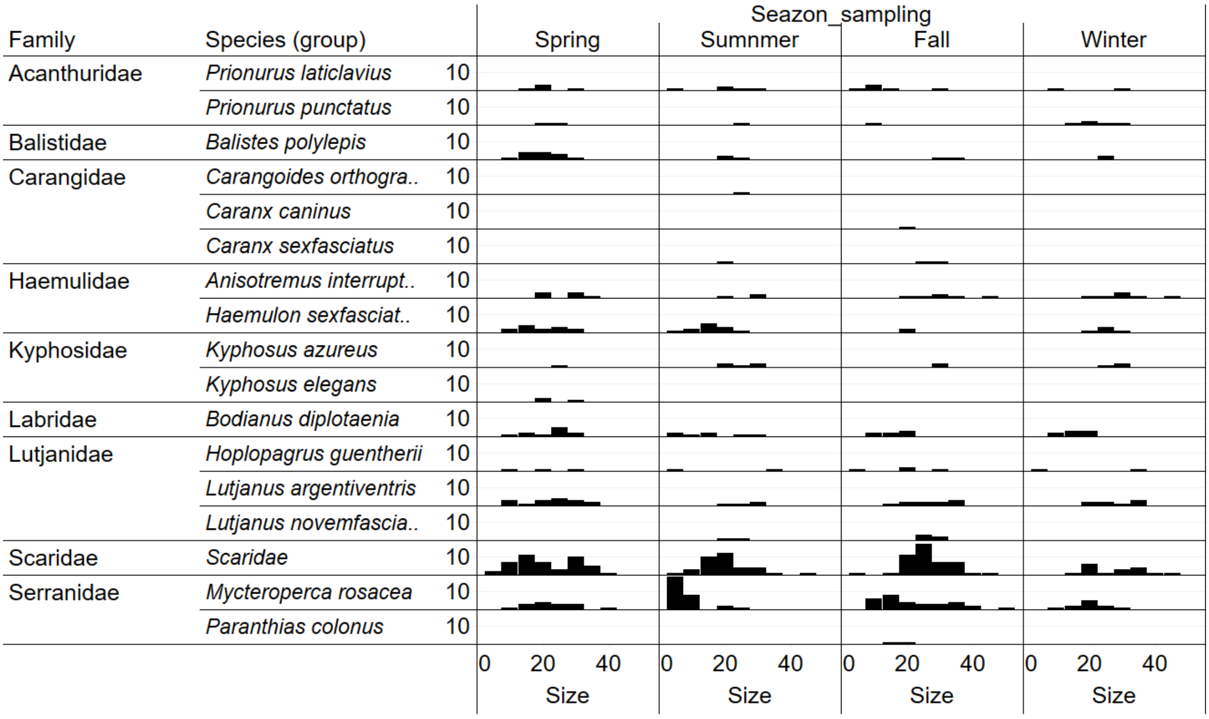

Figure 3. Seasonal size distribution of selected fish species grouped by family. The histogram plots represent the size structure of individuals recorded in spring, summer, fall, and winter. Each row corresponds to a different species considered as commercial fishing resources.

Spatial and seasonal patterns in fish biomass were evident across trophic groups based on the 2024 underwater surveys. Herbivorous fish exhibited the highest biomass concentrations, particularly during the fall, with localized hotspots in the central region of the study area. This seasonal peak was clearly distinguished by larger and more intensely colored markers, indicating values approaching 1.6 tons per hectare. Piscivorous and carnivorous fish displayed relatively consistent spatial patterns throughout the year, although their biomass values remained moderate compared to herbivores. To understand deeply these stational patters, more detailed studies are needed.

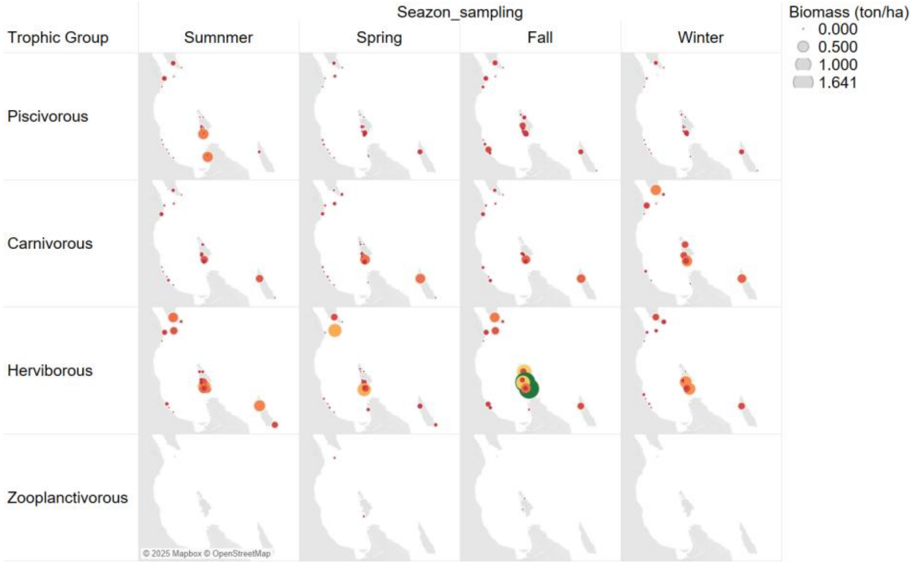

Figure 4. Seasonal and spatial distribution of fish biomass (tons per hectare) by trophic group based on underwater surveys conducted in 2024. Each panel represents a combination of trophic group (rows) and sampling season (columns). Circle size and color reflect biomass magnitude, with larger and darker circles indicating higher biomass values.

Photos of underwater surveys team and some species into de rocky reef ecosystems surveyed in this project from 2024-2025

b) Surveillance Activities

Throughout the monitoring efforts, a total of 167 patrols were conducted, covering 20,875 km over 1,058 hours. These included 111 marine patrols (12,277 km, 657 hours) and 56 terrestrial patrols (8,598 km, 401 hours). The number of patrols varied monthly, peaking in October (17 patrols) and reaching the lowest in December (2 patrols), with marine patrols consistently outnumbering terrestrial ones. Collaboration with authorities was a key aspect, involving CONAPESCA (51 patrols), SEMAR (45), PROFEPA (15), CONANP (6), FONMAR (2), FGR (1), and SEGURIDAD PÚBLICA (1), with some patrols including multiple agencies. A total of 327 activities were recorded, of which 64.53% were legal, 21.10% were illegal, and 14.37% had no specific classification. These efforts contributed significantly to achieving the project's objectives.

Glossary of Institutions Involved in Surveillance Patrols

CONAPESCA (51 patrols)
National Commission of Aquaculture and Fisheries
SEMAR (45 patrols)
Mexican Navy (Secretaría de Marina)
PROFEPA (15 patrols)
Federal Attorney for Environmental Protection
CONANP (6 patrols)
National Commission of Natural Protected Areas
FONMAR (Not Authority)
Fund for the Protection of Marine Resources (Baja California Sur)
FGR
Federal Attorney General's Office
PUBLIC SECURITY (1 patrol)
Public Security Forces (municipal or state)

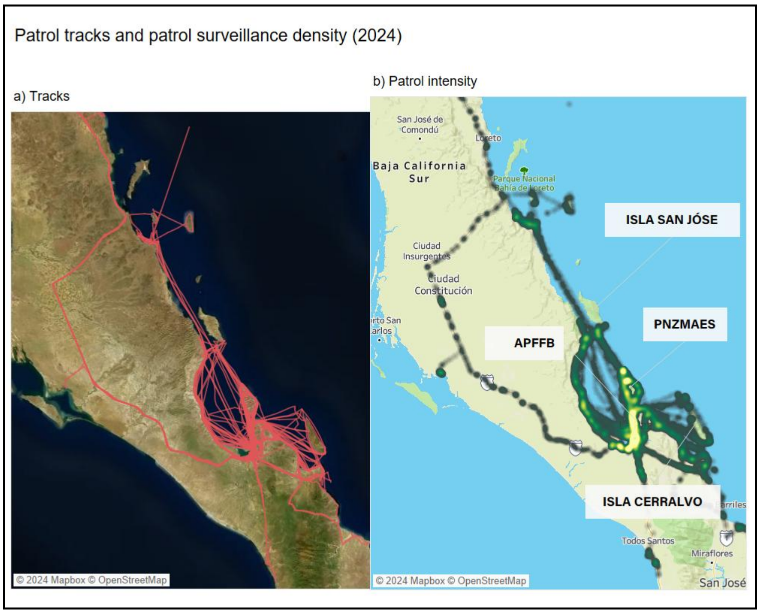

Figure 5. Georeferenced surveillance patrols deployed during 2024 to detect and dissuade illegal fishing activities. The map highlights the spatial distribution of patrol efforts across monitored areas.

The spatial distribution of illegal fishing activities detected between 2021 and 2024 reveals distinct hotspots along the coast of La Paz Bay. This heatmap, generated from community-based surveillance data, shows that illegal activities are highly concentrated near the southern and central portions of the bay, particularly around the urban coastline of La Paz and adjacent coastal zones. These hotspots coincide with areas of high marine traffic and accessible fishing grounds. Lesser intensities are also observed along the eastern coastline toward Los Barriles and in isolated spots along the northwestern coast. The persistence of these hotspots over three years underscores the need for targeted enforcement and adaptive surveillance strategies in these priority areas.

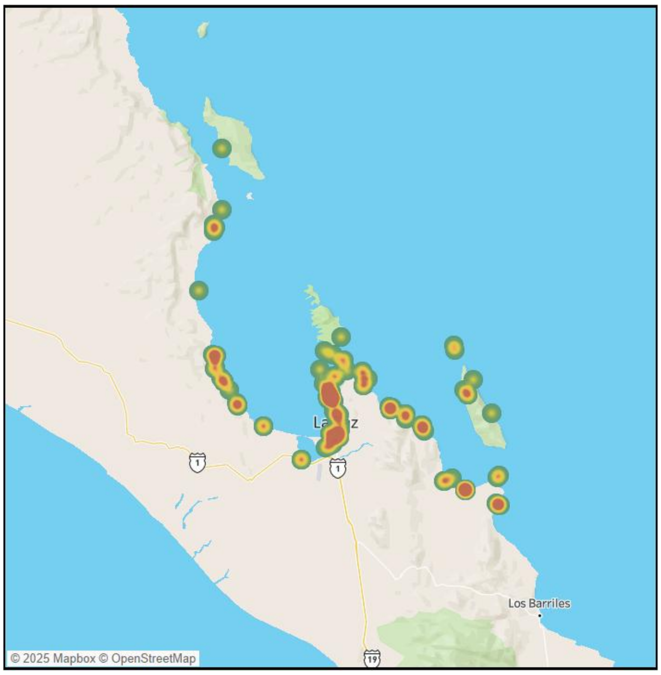

Figure 6. Hotspots of illegal fishing activities recorded from 2023–2024 in La Paz Bay. Red areas indicate regions with high levels of detected illegal fishing activities.

C).- Estimations of octopus abundance to describe atractiveness of illegal areas usign a novel methodology in collaboration with formed-illegal fishers.

To better understand octopus abundance in areas where illegal fishing targeting this resource has been detected, we adapted a novel survey method based on the fishing techniques of former fishers. This adaptation was necessary because the PROMARES methodology showed limitations in detecting octopus, especially in certain regions. The use of local fishing knowledge proved highly effective in revealing the presence and distribution of this species. A comparative analysis of octopus sightings across different regions of La Paz Bay reveals substantial differences between the two monitoring methodologies: PROMARES (left panel) and the Fisher Methodology (right panel). While PROMARES registered only a limited number of octopuses—particularly in San Juan de la Costa and only marginal counts in other areas—the Fisher Methodology recorded significantly higher quantities across all regions. For instance, in San Juan de la Costa, more than 60 individuals were recorded using the fisher-based approach, compared to fewer than 10 with PROMARES. This stark contrast underscores the greater effectiveness of collaborative approaches that integrate traditional ecological knowledge, as former fishers have fine-scale insight into species behavior and habitat.

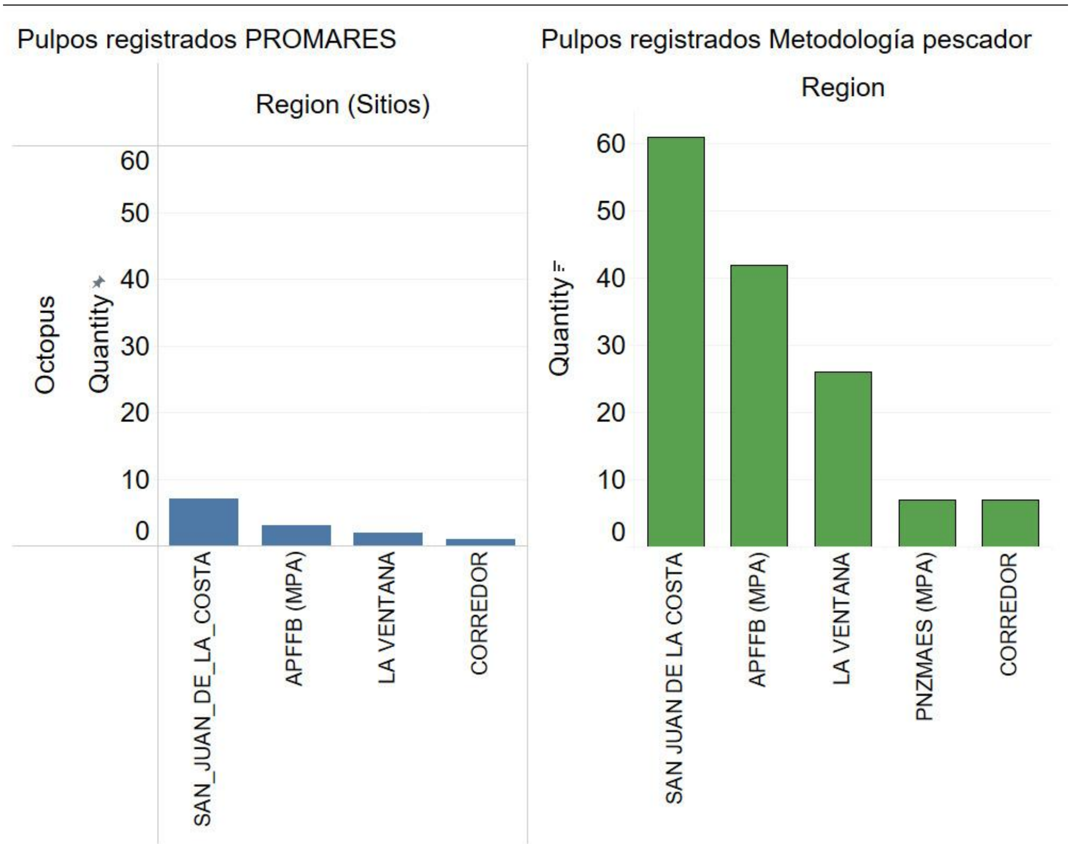

Figure 7. Comparison of octopus sightings by region using two different monitoring methods in La Paz Bay. The left panel shows data from PROMARES monitoring efforts, while the right panel displays results from the Fisher Methodology.

Clear seasonal patterns and notable differences between direct octopus sightings ("Pulpo") and caves with evidence of fishing activity ("Cueva con evidencia pesca") across La Paz Bay.

Spring: This season exhibits the highest number of caves with fishing evidence, particularly in one site where over 50 cases were recorded. In contrast, direct sightings of octopuses were low and relatively consistent across sites, not exceeding 10 individuals.

Summer: A high number of fishing evidence was again recorded, though more evenly distributed across sites. Direct octopus sightings also increased slightly compared to spring but remained significantly lower than the number of fishing-evidence caves.

Fall: Only one monitoring site registered data in this season, with 40+ caves showing signs of extraction and about 15 octopus sightings, indicating a strong localized presence and fishing pressure.

Winter: Although the total counts dropped, both caves and sightings remained present across several sites. This suggests that fishing activity and octopus presence continue year-round, albeit at reduced intensity—likely due to weather or accessibility conditions.

Across all seasons, **the number of caves with fishing evidence was consistently higher than the number of octopus sightings**, suggesting ongoing extraction pressure that may not be fully captured through direct observation alone. The greater variability and higher values in the cave evidence category emphasize the importance of indirect signs as a more sensitive indicator of octopus presence and human interaction, particularly when integrated with fishers' ecological knowledge.

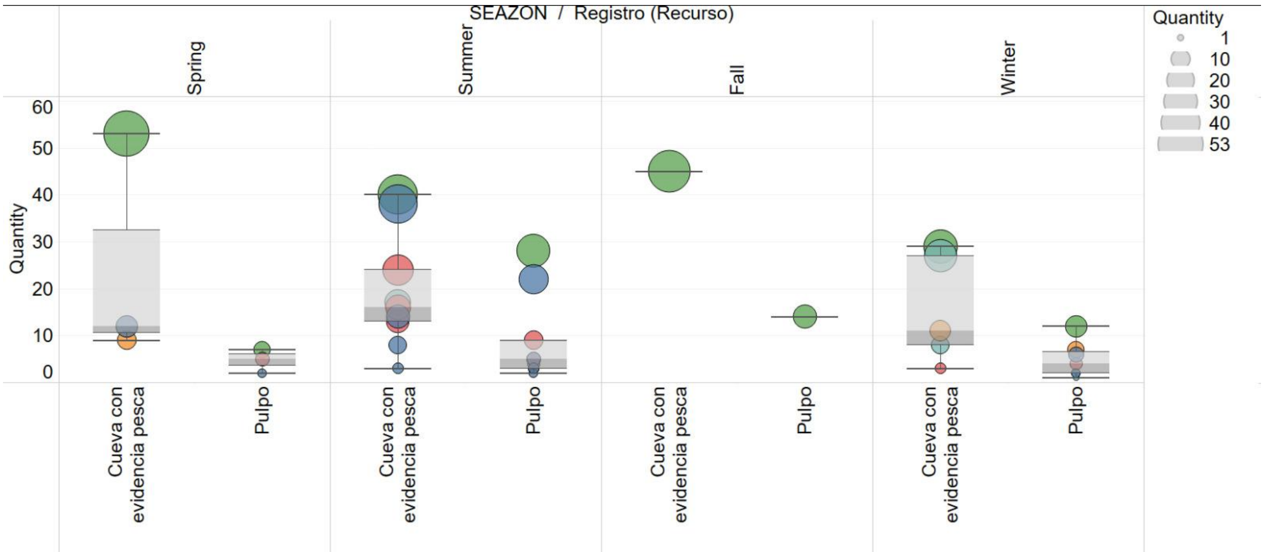

Figure 8. Seasonal variation in octopus sightings and caves with evidence of fishing activity in La Paz Bay using the Fisher Methodology. Each panel represents a different season (Spring, Summer, Fall, Winter), and the two categories on the x-axis show direct sightings of octopuses and observations of caves with signs of fishing (e.g., traps or remains). Circle sizes represent the quantity recorded, with larger circles indicating higher counts. The data show that caves with fishing evidence are consistently more abundant than direct sightings, particularly during Spring and Summer. This suggests ongoing extraction activity and highlights the value of fisher-based monitoring in detecting both direct and indirect indicators of octopus presence across seasons.

Octopuses observed during this project. All materials will be shared through social media posts.

3. Explain any unforeseen difficulties that arose during the project and how these were tackled.

The strong winds during winter and spring were significant environmental challenges we faced during this project. These seasons made navigation particularly difficult, and the frequent port closures limited our available days for surveys. We had to be ready for the perfect weather window to carry out our surveys.

4. Describe the involvement of local communities and how they have benefitted from the project.

Even though the project does not directly involve local communities, we use the information and knowledge obtained from surveillance activities and underwater surveys in two main ways. First, we have a program to strengthen community-based surveillance efforts. Through this, we share strategies and metrics with local teams to help them evaluate and improve their performance. Second, we've launched a continuing education course at the local university in La Paz (UABCS), where we share the results and insights from this project to engage students and citizens in the responsible use of natural resources

5. Are there any plans to continue this work?

Yes, we plan to create a citizen science program to evaluate the recruitment of commercial species in the area, based on the results observed in this project. We also aim to continue monitoring octopus abundance and fishing activity. On the other hand, now that we have a general overview of the resources, we want to focus on measuring changes in fish biomass within a specific area that has strong surveillance coverage. This would be the best way to demonstrate the effectiveness of our surveillance program.

6. How do you plan to share the results of your work with others?

We are preparing videos and social media content about this project. In addition, more detailed results will be shared through presentations at local forums and scientific conferences.

7. Looking ahead, what do you feel are the important next steps?

First of all, all the information from this project will be used in the final analysis of my PhD studies, which focus on understanding the factors that make an area attractive for illegal fishing. Although I'm expected to graduate in June 2026, this will be submitted as the third paper of my thesis by the end of that year. After that, we will continue working on the project to professionalize surveillance activities with various groups we are currently training across Mexico. As the coordinator of Collaborative Science at Red de Observadores Ciudadanos A.C., my goal is to continue applying science and developing tools to improve surveillance efforts in my region and other areas facing similar challenges.

8. Did you use The Rufford Foundation logo in any materials produced in relation to this project? Did the Foundation receive any publicity during the course of your work?

Yes, the Rufford Foundation logo was primarily used during presentations and will also be included in the creation of social media materials related to the project.

9. Provide a full list of all the members of your team and their role in the project.

Involved institutions

Red de Observadores Ciudadanos A.C. (ROC)
Centro de Investigaciones Biológicas del Noroeste (CIBNOR)
Universidad Autónoma de Baja California Sur (UABCS)

Project Lead, Underwater Surveys, and Data Analysis

Ramiro de Jesús Arcos Aguilar – PhD Candidate (CIBNOR, ROC)

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Boat Captains and Former Fishers (Octopus Methodology Development)

Ricardo Calderón Amador – ROC
José Luis Ceseña Calderón – ROC

10. Any other comments?

Thank you for your support; it has been vital to both my PhD studies and the research