Final Evaluation Report

Your Details	
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Project Title	Valuing Fishers' Ecological Knowledge in the North of Peru
Application ID	26779-1
Date of this Report	12/03/2023

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
Develop a framework to collect and analyse fisher's ecological knowledge			■	A methodological framework was developed as part of the research project, which was based on interviews with fishers and was able to quantitively analyse fisher's ecological knowledge
Determine a relative fish abundance index based on fisher's ecological framework			■	By applying the designed framework, it was possible to estimate relative fish abundance index and validate its application on the ground.
Comparing abundance perceptions of fishers based on their experience			■	The hypothesis of the shifting baseline syndrome was tested, which proposes that each new generation of fishers might think that the amount and size of fish they catch is normal, even though it has declined significantly over time due to overfishing and other factors.

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

A replicable, scalable, and simple framework has been developed that has the potential to reconstruct time series of fish abundance, maximum catches, and other fishery-related indicators.

We were able to develop a simple framework that allows to make use of fishers' ecological knowledge (qualitative information) to estimate different fisheries indicators (quantitative information). Interviews were held with over 30 artisanal fishers in five different fishing communities in northern Peru (**Figure 1**), totalling 155 interviews. These were performed following the ethical considerations proposed by the Peruvian University Cayetano Heredia and had its protocols approved by the Institutional Research Ethics Committee.

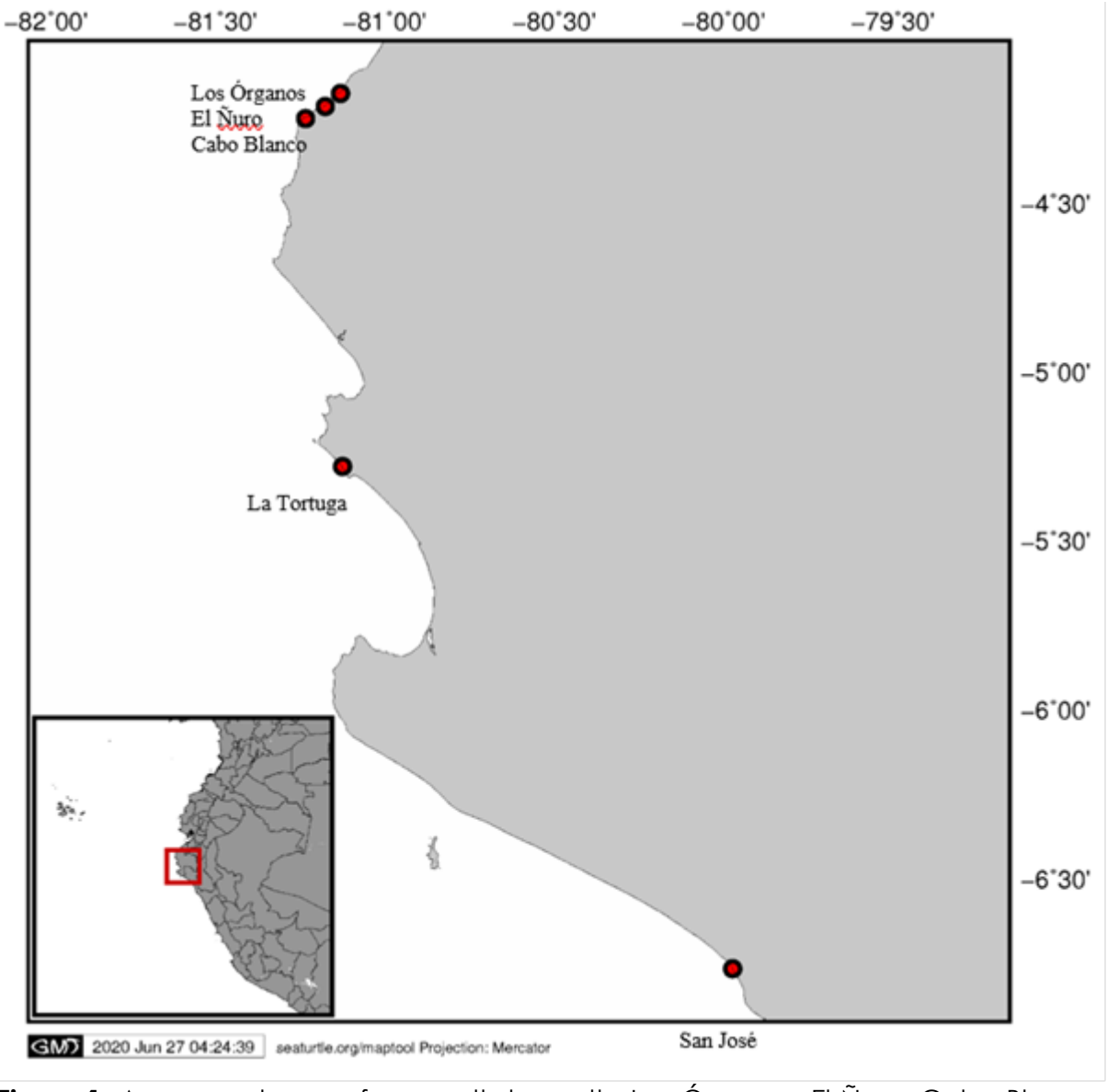

Figure 1: Assessment areas from north to south: Los Órganos, El Ñuro, Cabo Blanco, La Tortuga, San José

Some of these fishing communities were close together and had similarities in the species they targeted, however in some cases they used different fishing gear to catch their fish. It is proposed that these subtle differences might have had some effect in the results. More details of the fishing communities, according to the I National Census of Marine Artisanal Fisheries can be found in **Table 1**.

Table 1: General information of the interviewed fishing communities

Fishing community	Region	Number of fishers	Main fisheries	Main fishing gear
Los Órganos	Piura	213	Peruvian hake, Peruvian rock seabass	Set nets
El Ñuro	Piura	207	Peruvian hake, tuna	Hook and line
Cabo Blanco	Piura	439	Peruvian hake, bighead tilefish, Peruvian rock seabass, jack mackerel, flathead grey mullet	Hook and line
La Tortuga	Piura	566	Mahi mahi, jumbo squid, Peruvian rock seabass, flathead grey mullet, Peruvian weakfish	Set nets, hook and line, squid jigs, longlines
San José	Lambayeque	1020	Rayas, Peruvian banded croaker, flathead grey mullet, bonito, jumbo squid, Peruvian weakfish	Set nets, purse seines, squid jigs, hook and line

This methodological framework shows that fishers' ecological knowledge can be a useful source of information. In that sense, information generated from fishers' knowledge can complement data-limited fisheries assessment methodologies. Results illustrate how this information can help to gradually tell the story of how a fishery has developed at different times. In that sense, qualitative information from the fisher's knowledge can be used and through different methodologies it can be processed to obtain quantitative information which can generate different fishery indicators that can complement the evaluation methodologies of data-limited fisheries.

In that sense, results indicate that all species evaluated have shown significant declines in abundance, and although a relative abundance index has been estimated, the decline that has occurred for the different species is categorical and was also reported anecdotally in the interviews by the most experienced fishers. Finally, it has been shown that abundance is perceived in a differentiated way between generations. This is important because if the phenomenon of shifting baseline syndrome is occurring, information about the past is being lost. For example, management decisions can be taking as reference points scenarios that underestimate abundance, or other indicators such as size, weights, among others.

In that sense, the three most important outcomes from this project are:

a) Abundance trends were able to be estimated showing a considerable decline over time

Individual estimates of fish abundance were provided by fishers for each decade since 1950, according to their experience. A fish abundance model was developed based on those estimates, which was then compared to each individual response to identify the level of consensus from the different respondents. A high level of consensus indicated that different fishers had a similar perception of fish abundance, providing greater robustness to the overall estimates of fish abundance models from the fishing communities. Likewise, similar responses among different fishing communities that resulted in a high level of consensus were grouped to estimate an overall model of fish abundance for certain species.

In **Figure 2** an example for the Peruvian rock seabass (*Paralabrax humeralis*) is shown, which indicated that perceived abundance had declined by more than 50% between 1950 and 2010. In this case the consensus index was estimated in 0.24 indicating a high degree of consensus (the closest to 0 the highest the consensus). Likewise, fish catches of Peruvian rock seabass were correlated with estimated fish abundance, finding a positive correlation. This means that when abundance was higher, so were fish catches. In that sense, recent low fish catches could be correlated to lower fish abundance. This same approach was applied for Peruvian weakfish (*Cynoscion analis*), jack mackerel (*Trachurus murphyii*), tuna (*Tuna sp.*) and bonito (*Sarda chiliensis chiliensis*). Overall, it was estimated that fish abundance declined between 45% and 80% since 1950.

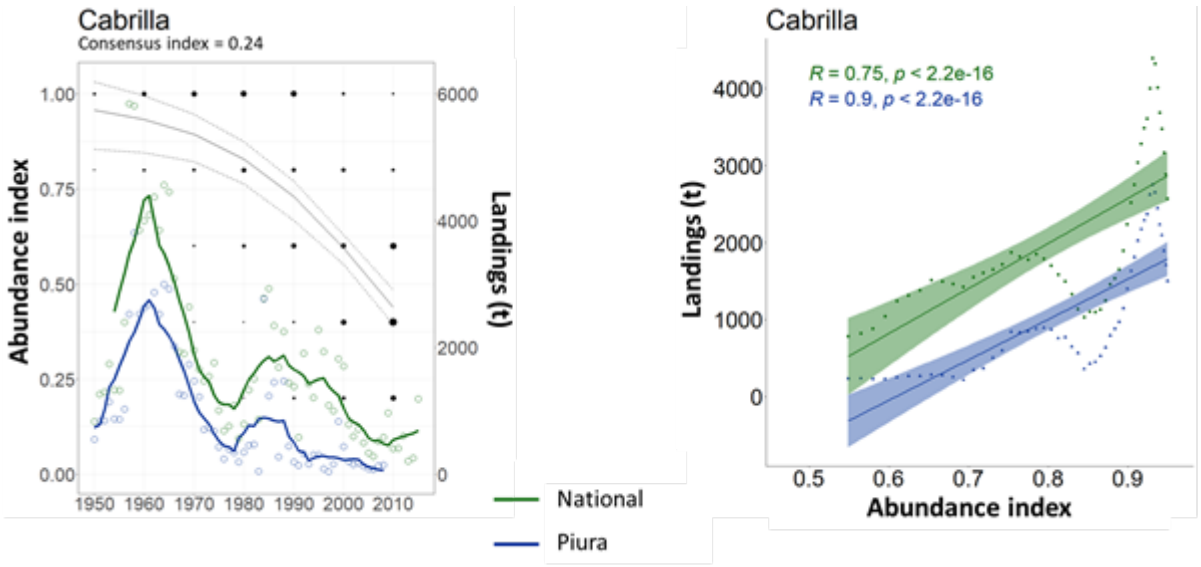

Figure 2: (a) Time series of abundance and landings of cabrilla, based on the estimation of the mean values and confidence interval of a fitted model. The solid line indicates the mean, and the dotted lines indicate the 2.5 and 97.5% confidence interval of the model. The dots indicate the different responses, and the size indicates the proportion of responses. In green colour the national landings and in blue colour the landings from Piura Region. (b) Scatter plot between landings and abundance, and Spearman's correlation coefficient.

b) The "shifting baseline syndrome" hypothesis was tested with fishers' perception of fish abundance

Interviewees age ranged from 22 to 94 years, resulting in a varied sample of fishers with different amounts of experience, and it is proposed that each generation of fishers will have different baselines of fish abundance and may perceive change differently, a concept that has been named as the "shifting baseline syndrome" (Pauly, 1995[1]). In that sense, to evaluate if there was a bias due to different perceptions and reference points according to the experience of the interviewees, the probability of obtaining different reports of HIGH (5-4) or LOW (1-2) abundance was estimated for three different periods according to the degree of experience.

A multinomial logistic regression was developed using the value of reported abundance for all species as the dependent variable, years of experience as the independent variable, and year of reporting value as a factor. In addition, the probabilities of responses between the youngest generation and the oldest generation, and consecutive generations for all periods were compared with a t-test to identify whether differences existed between groups. This was done to assess whether a shifting baseline syndrome was occurring, and the fishers' knowledge was not being fully transferred between generations.

As we wanted to test if there were any biases between the perception of age abundances, we estimated the response probabilities for high and low abundance levels according to the years of experience and for different decades. **Figure 3** shows that fishers with less experience are more likely to answer with high abundances for the three periods evaluated, while a more experienced fisher is more likely to respond with low abundances for the three periods evaluated. This could be indicating that there would be a bias according to experience levels and how fishers initially perceive the abundance reference points. By having a reference point at which the species were more abundant, changes are greater at a relative level, and therefore the perception of abundance change (decline) would be greater. At a statistical level, there were significant differences between the probabilities of the different generations, so it is considered that each generation has a different perception of what is abundant.

"3rd Generation" ≠ "2nd Generation" ≠ "1st Generation"

[1]*Pauly, D. (1995). Anecdotes and the shifting baseline syndrome of fisheries. Trends in ecology & evolution, 10(10), 430.*

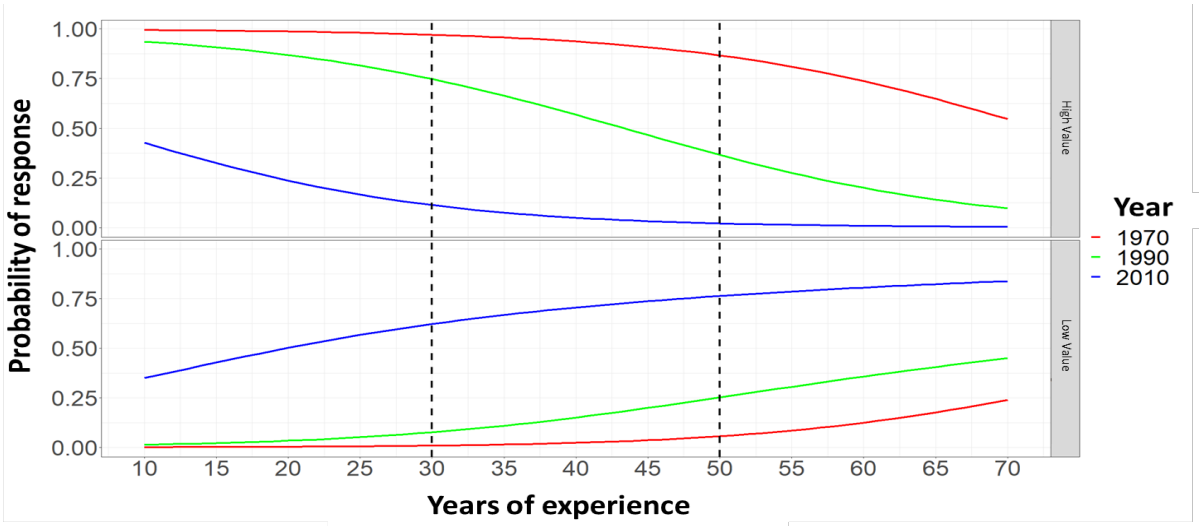

Figure 3: Predicted probability of reporting a HIGH (5-4) or LOW (1-2) abundance value by fishermen of different ages during different periods by a multinomial logistic regression, the vertical dashed line denotes the three dummy generations.

c) Maximum catch levels were estimated for different species across the time-series.

Maximum catch levels were estimated to have information about moments in which fishing activity was more intense. Generalized Additive Models (GAM) were used for this purpose, and only species for which more than 20 observations were available were analysed. The variables "best year" and "years of experience" were used to model the "best catch", and the model with the best fit was chosen.

Results of maximum catch estimates could only be made for Peruvian hake, Peruvian rock sea bass and Peruvian weakfish due to the amount of data available for these species. For example, for the Peruvian rock seabass catches have been steadily increasing throughout the study period (**Figure 4**). Around the decade of 1960s on average the maximum catch could be 100 kg, while in 2020 the maximum catch had increased by approximately 50% to 150 kg on the best of days. This increase has continued to occur, even though according to fishers' perception the abundance of Peruvian rock seabass is decreasing. On the other hand, the most experienced fishers reported the lowest levels of maximum catches, possibly because their fishing techniques did not change much over time, as younger fishers may have done. Indeed, it is the fishers with between 30 and 40 years of experience who have had the highest levels of maximum catches.

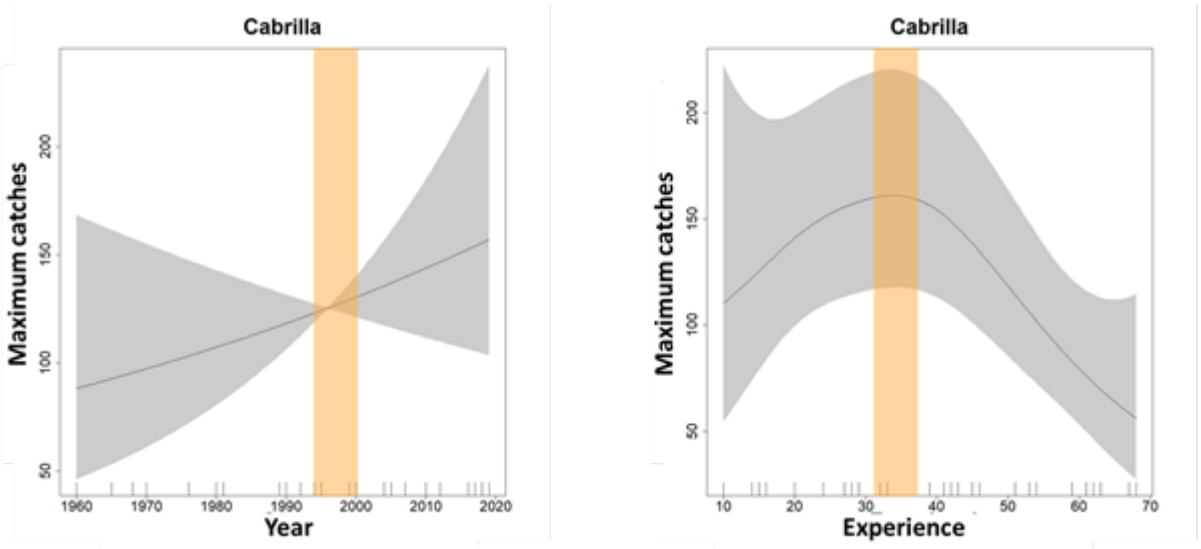

Figure 4: Maximum catches estimation for Peruvian rock seabass

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

Fieldwork took longer than expected as collecting fishers' ecological knowledge took longer than initially considered. Interviews took longer than initially planned, as in some cases additional information was shared by the interviewees which extended conversations up to 2 hours. In that sense additional fieldwork days were required, which were possible as flight expenses on some occasions were covered through other projects. Altogether 155 interviews were carried out throughout 2019 and were used as part of the analysis. However, these only include five out of the six fishing communities initially considered, as the COVID-19 pandemic started right as the work was being executed in the last fishing community. A minimum sample of 30 interviewees per community was required, and only 15 interviews were able to be carried out. Efforts were made to try and integrate them collectively into the overall results, but after discussing with my master's thesis advisor it was decided to consider communities in which fieldwork was completed.

The start of the pandemic also delayed part of the analysis of the research, however it was completed by August 2020. However, as it was part of my master's thesis it needed to be submitted and defended, which ended up happening in January 2021 as delays occurred within the university. Finally, even though the thesis got approved the COVID-19 situation made it complicated to travel to the fishing communities that collaborated throughout the project, and this ended up happening between August and September 2021. Overall, COVID-19 generated delays as several adjustments were done in the ways work was being done, however it was possible to overcome.

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

Fishing communities of Los Órganos, El Ñuro, Cabo Blanco, La Islilla, La Tortuga and San José participated with their inputs through their fishers' ecological knowledge

and were the foundation of the project. Moreover, representatives from this fishing communities were contacted afterwards to share the results and insights generated from their experience (**Figure 5**). In that sense, this project has highlighted the importance of valuing fisher's ecological knowledge, as it can generate useful information for fisheries management. This project could not have been done without the selfless and generous support of many fishers who shared their knowledge and experiences with me.

5. Are there any plans to continue this work?

With the approach and methodological framework tested it is possible to scale it and replicate it at a bigger scale, however such mission requires government engagement and political will. Likewise, recommendations stemmed from the project that could be implemented in the future to improve and curate the methodological framework and make it more robust. In that sense next steps have been identified but scaling up is a challenge which require considerable efforts.

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

In the political sphere results have been shared with the Ministry of Production, which is planning to develop a new Censo Nacional de la Pesca Artesanal en el Ámbito Marítimo (National Census of Artisanal Fishing in the Maritime Area). It has been suggested that key questions can be incorporated within the census form following the framework developed. They have not yet reached the stage of developing the form, but once they do, input and recommendations can be provided. Likewise, results have been shared with the National Institute of the Sea, which performs each 5-10 years an artisanal fishers survey and could eventually include ecological knowledge questions into their questionnaire.

In a broader dissemination context, it is expected for results to be shared at international conferences and through scientific peer-reviewed articles. Results have already been shared as my master's thesis dissertation (summa cum laude), and currently the published thesis can be accessed in the Peruvian University Cayetano Heredia Repository and at ResearchGate where a more thorough explanation of results can be found. Likewise, results were presented during the Open Science Conference on Eastern Boundary Upwelling Systems (EBUS): Past, Present and Future & Second International Conference on the Humboldt Current System held in Lima in September 2022 (**Figure 6**).

Figure 5: Meetups with leaders from fishing communities (starting from the top from left to right: Carlos Bayona – La Islilla, Juan Emilio Fiestas – San José, Manuel Rey Purizaca – La Tortuga, José "El Che" Pazos – Los Órganos, Marcelino Gonzáles Silupu – El Ñuro)

Figure 6: Final slide of oral presentation during EBUS Lima 2022 thanking fishers' support.

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

It is important for fisheries to be seen holistically and engage on the social aspects of it. Further studies on traditional ecological knowledge need to be developed, and there is a small but growing trend in the region. This is exemplified by the EBUS Lima 2022 event that was held in September 2022, which had a specific session titled *"Engaging citizen science, traditional knowledge, and scientific research for the formulation of management strategies, pollution mitigation and public policies in EBUS"*. In that sense, mainstreaming traditional knowledge is key as it needs to be part of the "toolkit" researchers have, as it broadens the set of recommendations, they can provide to policy makers.

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?

The Rufford Foundation Logo was used in my master's thesis defence and the foundation was also acknowledged during the presentation. Likewise, the foundation has been also acknowledged in the thesis which is published in the Cayetano Heredia Peruvian University repository. Finally, during the oral presentation made during the EBUS Lima 2022 event credits were given to the foundation by using its logo (**Figure 7**).

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

Nicolás Rovegno (myself) led the project development, implementation and analysis with guidance of **Juan Valqui** as my thesis advisor.

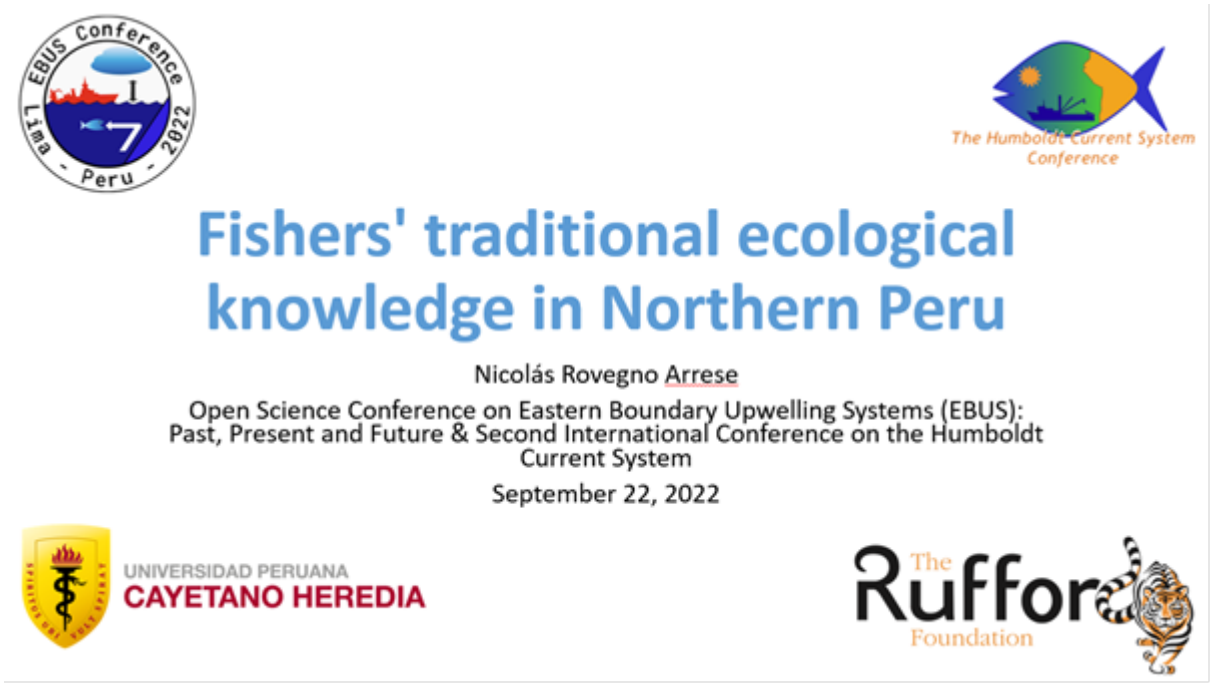

Figure 7: Presentation made during EBUS Lima 2022.