FELLOWSHIP SUMMARY REPORTS

OECD Fellow: César Vilas Fernández

Title of Fellowship: " Disentagling ecosystem functioning of a nursery area by wavelet analysis of long term ecological time series: integrative ecosystem assessment of the Guadalquivir estuary for Gulf of Cádiz fisheries sustainability".

Relevant OECD Theme: Theme I: "Managing Natural Capital for the Future" of the OECD Co-operative Research.

Program Host institution: Yale University- Department of Ecology and Evolutionary Biology, USA

Host Scientist: Professor David Vasseur

Period: 1 March to 19 July 2017

Consent: This report can be included on the Co-operative Research Programme's website

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1. What were the objectives of the research project? Why is the research project important?

The general aim of this present work was to understand the general mechanisms and complex interplays determining spatio-temporal and time-scale evolution and covariation between species in the aquatic community of the Guadalquivir estuary through the application of wavelet analysis to time series of monthly species density and environmental data for 1997-2015.

The specific goals were:

- to estimate which temporal scale or frequency explains better the observed density variance of main species in the Guadalquivir estuarine ecosystem, identifying the dominant population cycles and how environmental forcing is affecting their population dynamic,
- to quantify general patterns in the times and scales at which synchronous/compensatory dynamics dominated the estuary community promoting coexistence and stability and which external factors determine the relative dominance among them,
- to determine and modeling the main predator-prey dynamics for fish juveniles-zooplankton trophic relationships and how environmental forcing and complex trophic interplays are controlling predation and competition processes in the estuary and,
- to asses the dependence of Gulf of Cadiz fish stocks, in particular, and of the marine ecosystem, in general, on the ecological processes and anthropogenic impacts occurring in the Guadalquivir estuary and how an Integrative Ecosystem Assesment can ensure fisheries sustainability.

This research will contribute to understand how the water and land management in the estuary is affecting the estuary ecology, and the development of models which will serve as a useful tool to predict and provide relevant scientific information and advice which will inform future policy decisions related to the sustainable use of natural resources and fisheries.

2. Were the objectives of the fellowship achieved?

In general, the research is still ongoing and the databases we compiled during the fellowship are being analysed. Main reason because the objectives are on the way to be completely achieved is that data cleaning and data manipulation for analysis took us more time than expected on our first planning, mainly because some mistakes on the Guadalquivir database. These errors were found at the beginning of the fellowship when we did the first analysis and I was learning new tools for data manipulation on R. However, finding and solving these mistakes (what took me some weeks) has been a great achievement by itself: we have cleaned this important and valuable dataset and set it ready to use. We are currently actively working on the analysis of time series of the complete biological-environmental data set I have compiled for the Guadalquivir and Gulf of Cadiz ecosystems. Previous results are leading us to interesting conclusions, which will fulfil the fellowship objectives. Our plan is to publish 2-3 papers during 2018 on ecology and fisheries international journals.

Furthermore, new questions and research lines have emerged during the analysis of the Guadalquivir dataset in Dr. Vasseur lab and interactions with his postodocs. The main has been to prepare and use it for the application of novel statistical tools on the synthesis on ecology. We have been working on the study of the relationship between biodiversity and the estuary ecosystem functioning with the novel package CAFÉ (Community Assembly and the Functioning of Ecosystems), developed by an international group of ecologist and to be published soon at a high rank ecology journal. With this tools, we are working on identifying which property, if species richness or community composition –even identifying which species or groups- are contributing the most to the juveniles fish biomass –hence, nursery functioning. Considering how the Guadalquivir community changes in an integrative way, rather than focusing on one axis of community structure at a time, together with the temporal wavelet analysis, will improve our ability to anticipate and predict changes in the estuary ecosystem function.

3. What were the major achievements of the fellowship? (up to three)

The research undertaken during this fellowship is directly relevant to Theme I "Managing Natural Capital for the Future" of the OECD Co-operative Research Program, which promotes research toward improving the sustainability of food production practices. We consider that the first big achievement has been the compilation and data tidying of an integrative time series dataset with biological and environmental variables at the Guadalquvir-Gulf of Cádiz area; following R coding specialists recommendations I have compiled the following time series:

- for aprox. the last 90 years: NAO index, dam freshwater discharges to the estuary, mean area precipitation, air temperature, and other climate variables.
- for the last 18 years: species densities and community evolution at the Guadalquivir, together with environmental variation, and fish stocks evolution for anchovy and sardine at the Gulf of Cádiz (by both commercial captures and independent acoustic biommas evaluation).

We are currently working with these dataset applying three types of methodologies: the planned Wavelet Analysis, but also two new ones: Empirical Dynamic Modelling time series analysis, and CAFÉ R package. We are developing the R codes for these analysis and producing different graphs and results. In addition, I also worked on the Guadalquivir food web analysis by network R packages and the assessment of Dr. Vasseur..

About our preliminary achievements, we can highlight

- based on our previous results, one of the main environmental conclusions is a relevant decoupling between natural cycles of precipitation and freshwater inflow or discharge to the estuary from the dam Alcalá del Río. Wavelet analysis shows a loss of coherence, mainly since 70´s between these variables, and predominantly after drought periods. While Precipitation time-scale variation remains on the 365 days scale, showing the seasonal rain seasons, the freshwater inflow seasonal time scale lose the year rhythm, causing relevant changes on salinity gradient and its time-scale variation at the estuary, again decoupled from the natural salinity cycle as expected by precipitations.

- if environmental water properties determine primary production at the estuary, how this decoupling will effect the estuary community? Trying to answer this question we analysed, for the 20 most abundant species, on one side the food web cluster –which species are eating similar or closer at the trophic web- and on the other side, the wavelet clustering during the 18 years –which species show similar time-scale variation and seasonal dynamics and/or pehnology. Surprising we found a very similar and parallel clustering from both independent datasets, what means that food web structure may determine the estuary time-scale use for each species, what might be leaded by lower trophic level components. An alteration of the food web base –detritus and phytoplankton-, through the alteration of estuary environmental properties as salinity regime and freshwater inflow, will affect the estuary nursery function, and fisheries at the end. In fact, wavelet analysis of anchovy juveniles biomass in the estuary and fishery landings show a reduction on last one after years of low biomass of anchovy and its main prey, mysids.

- the finding of a significant change of predator-prey synchrony through the years, with some years where both parts showed some delayed, as expected on a predator-prey cycle –predator following prey- but some years when they where totally on phase, what means they experience high biomass at the estuary at the same time. The on-phase period coincide with low freshwater inflow -2006-2009-, what might be related with the natural salinity gradient alteration and observed low concentrations of chlorophyll A (indicator of phytoplankton). This phenomena could affect survival of predators –fish juveniles in our case- leaded by the increase of competition between themselves and the alteration of natural population dynamic of the prey –mysids in that case.

4. Will there be any follow-up work?

The research work is still ongoing and we are actively analysing, making new type of graphs on synchrony/complementarity situations between species and coding so we can give robust statistical results. We are preparing at least 2-3 articles to be published on a high rank ecology journal. The publication should appear in the next year.

This fellowship has been the start of a great collaboration with the Professor David Vasseur and his team which is still ongoing and we will keep in the next future. We are collaborating now on two different but complimentary research lines:

- the aim of this fellowship, working directly with Dr. Vasseur and his PhD student Franz Simon on the development of new analytical and graphic tools based on wavelets to study synchrony and complementarity on ecosystems.

- the use of Guadalquivir data on new open software R package to analyse complex ecosystem evolution, working directly with Dr. Vasseur´s postdoc Colin Kremer and Elodie Parain, we are working on the analysis of how Biodiversity is related to Biomass or Ecosystem Function in the Guadalquivir Estuary and on the seasonal evolution of food webs.

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5. How might the results of your research project be important for helping develop regional, national or international agro-food, fisheries or forestry policies and, or practices, or be beneficial for society?

We are just starting a new monitoring programm in the Guadalquivir estuary and the results of this research will be leading new research lines, for example the importance of a better knowlodge of the base of the food web and its environmental forcing. I am also transfering these previous results, and later conclusions and scientific work, to the Fisheries and Aquaculture Department, who are the responsible of developing the fisheries policy and marine reserves declaration in Andalucia. My Institution is part of the Agricultural and Fisheries Ministry of the Andalucia Government, so I am actively involved and continuously informing by reports to policy and management teams as well as politicians. The Guadalquivir LTER dataset is the main outcome of the special interest and funding through our Agency from the Fisheries and Aquaculture General Division, in the Agricultural and Fisheries Ministry of the Andalucia Government.

Our results should lead to a change on the water managing criteria by the Guadalquivir Water Agency, specifically promoting some freshwater inflow, - it can be defined by measuring salinity conditions at the estuary- so the ecosystem functioning during rainy seasons is guaranted, as well as the nursery function.

The relevance of this ecosystem for Gulf of Cádiz fisheries stocks that we are demonstrating with this research will support the future mantainance of the “Guadalquivir Estuary Fishing Reserve”, not only protecting space and fishing activities in its area, but more importantly promoting a new time management of external factors affecting processes in the estuary.

I am also organizing for the next months stakeholder and citizenship meetings and talks to inform about the importance of this ecosystem for biodiversity and fisheries.

6. How was this research relevant to:

The objectives of the CRP: our research will strengthen the scientific knowledge about the ecosystem functioning of coastal ecosystem of special interest for local fisheries, in this case because the estuary nursery function. Finding new links between different ecosystem components, how is the environmental forcing leading the estuary processes and how fish species are interacting with their prey depending on different water regimes is crucial for developing an Ecosystem Based and Integrative Managament.

The CRP research theme: The research focused on the integrative and time scale analysis of community structure, densities and functioning of a relevant ecosystem for the nursery function of commercial fish sepecies for the Gulf of Cádiz, and how water management in the Guadalquivir estuary could be related with changes on this functioning and the evolution of fisheries captures. Our research is central to several of the components of Theme I "Managing Natural Capital for the Future" :

- *Water*: our results show how water management from dams based only on agriculture needs can alter natural cycles on estuaries and coastal ecosystem.
- *Biodiversity:* increasingly coming to the forefront of the agriculture, forestry and fisheries policy debate. At the Guadalquivir Estuary, human water management is not only influencing juvenile fish biomass, but also biodiversity, by the loss of salinity gradient and decrease of nutrient and detritus entrance. We are studying how biodiversity is related to ecosystem functioing at this estuary. Climate change scenarios can lead to a more restrictive water retention, what could directly alter the estuary ecosystem functioning reducing even more its seasonality.
- *Aquaculture and Fisheries*: the estuary is an important provider of fishes because its nursery function. This function depends on biodiversity and community structure, which in turns depend on a sustainable water and landscape management of the Guadalquivir estuary.

7. Satisfaction

The OECD fellowship fulfilled all my expectations at Yale:

- Having the opportunity of working at a high level institution as Yale University has been a great experience for many reasons: having access to great facilities like Yale library and the main scientific journals; the possibility of weekly attending to high level scientists talks on ecology and environmental science; meeting new researchers and postdocs, all of them of high scientific skills, working on different topics has expanded my research network, but specifically even starting new collaborations with some of them.

- Dr. Vasseur Lab has hosted kindly and supported me on my work during this time, I was immediately accepted on their group, lab meetings and discussions and I feel now a part of it.

- Although the work to do has not been totally completed at the fellowship time as we planned, we are very happy because the project opened new and interesting new questions and we realized the dataset has a big potential. The project is still opened, codes for new and novel analysis are being developed and we are preparing several scientific papers.

- Will the OECD Co-operative Research Programme fellowship increase directly or indirectly your career opportunities?

Of course YES. Ahead of learning new statistic and data management skills, I have been attending to Ecology classes and discussing my project and related topics with high rank ecologists at Yale, so my knowledge on ecology functioning and concepts has been expanded. I think this is great to answer project questions and create new and competitive projects on the estuary and fisheries ecology in the Gulf of Cádiz.
But not less important, again I have met new people to work with so my career opportunities will increase.

Finally, the papers we will publish during the next year will improve my CV and let me access new fellowships, projects and jobs.

- Did you encounter any practical problems?

No, the economic fellowship conditions are really good and enough for the family daily life at USA, and the fellowship management has been extraordinary from the OECD personal.

- Please suggest any improvements in the Fellowship Programme.

Sincerely, I didn´t have a previous good idea about OECD projects, programmes and mission, and I discovered you do a very important work, with this fellowships, publications, etc…
I think a good idea will be to organize meetings with the fellows so we can also know what other people is doing, know better the institution and also explore how we can collaborate or participate in OECD, application for projects, developing publications, panels or topics collaborations or counselling, etc..

8. Advertising the Co-operative Research Programme

- How did you learn about the Co-operative Research Programme?

I knew through an email sent to the researchers from my Institution and by other colleages.

- What would you suggest to make it more "visible"?

I´ll try to communicate and advertise it better in ecology and environmental journals, professional associations, trying to reach the academic circles, where I think the OECD fellowships and activities are not well known.