

Alba Ardura and M<sup>a</sup> Trinidad Pérez  
(editors)

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# Sustainable Fisheries and Global Change

Aula de Investigación sobre Recursos Naturales



# **Sustainable Fisheries and Global Change**

**Alba Ardura and M<sup>a</sup> Trinidad Pérez  
(Editors)**



Universidad de Oviedo

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Universidad de Oviedo

# International Workshop

## *Sustainable Fisheries and Global Change*

*Online, 25<sup>th</sup> November 2021*

### *Workshop Summary*

Sustainable Fisheries and Global Change 2021 is an INTERNATIONAL ONLINE WORKSHOP for Fishermen, Stakeholders, Researchers, Managers, Teachers, Students and Citizens concerned about a subject of hot topicality in a worrying Global Change scenario. It is organized by the Research Group on Natural Resources ARENA (University of Oviedo), the Ocean Observatory of Asturias (OMA), the Institute of Biotechnology of Asturias (IUBA) and the University of Oviedo Foundation and is coordinated by Prof. Eva GarciaVazquez, Prof. Yaisel J. Borrell, Prof. Eduardo Dopico and Prof. Gonzalo Machado-Schiaffino and organized by Alba Ardura and Maria Trinidad Pérez (University of Oviedo). The event is sponsored by three different research projects: Ecosifood ([ecosifood.com](http://ecosifood.com)), Global Hake ([arena.grupos.uniovi.es](http://arena.grupos.uniovi.es)) and Ecomarine (<https://ecomarine-project.eu/>) and also by two International Master Programs: The Marine Conservation Master Degree at University of Oviedo ([unioviedo.es/mcml/](http://unioviedo.es/mcml/)) and the Erasmus mundus program in Marine Biological Resources ([imbrsea.eu](http://imbrsea.eu)).

### *Objectives*

Marine capture fisheries are the last major international industry based on the hunting and gathering of wild animals. However, this sector is under vulnerable conditions mainly due to political or economic interests, overexploitation of species and the effects of environmental changes. Due to its social and economic importance, the Fish and Agriculture Organization (FAO) has recently stated and reinforced the need for a social and global protection of this sector in different areas. The Sustainable Development Goals includes the protection of the planet, among others, and were adopted by all UN Member States in 2015, as part of the 2030 Agenda for Sustainable Development. In particular, the goals 12 and 14, are related with the sustainable consumption and production patterns and conserve and sustainably use the oceans, seas and marine resources, respectively.

In a scenario of increasing global demand for marine resources, a higher knowledge about biological data from fish stocks as well as a correct commercial product traceability is needed to achieve this sustainable fishing. Moreover, understanding the effects of climate warming and pollution on fisheries will be required to design recommendations for proper management of the fisheries resources. Finally, the transfer of this knowledge to societal stakeholders such as fisheries managers, environmental authorities and NGOs will be a key aspect to achieve a Sustainable Fisheries. Sustainable Fisheries and Global Change 2021 invites the fishermen, academic community, port authorities, stakeholders and citizens in general, to present and discuss their initiatives and experiences with the aim of evolving from Fisheries to Sustainable Fisheries beyond 2030.



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Online, 25<sup>th</sup> November 2021

# Global challenges to fishing resources



# International Workshop

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### Nursery and fish provisioning ecosystem services delivered by a coastal lagoon (Ria Formosa, Portugal)

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The nursery and fish provisioning services of the seagrass and unvegetated habitats of the Ria Formosa, a coastal lagoon in southern Portugal were evaluated using a multi-method approach. Monthly beach seine samples in 17 vegetated and 24 unvegetated locations were used to study habitat enhancement of density and biomass of 96 fish species. In addition, enhancement of survival, growth and production of single cohorts of 12 of the most important commercial species were calculated. Tagging studies revealed high site fidelity, which allows the comparison of habitats. The overall seagrass density for all 96 species was 1.89 and 2.03 times greater than for unvegetated habitats, in numbers and in biomass, respectively. Vegetated habitat enhanced survival in six of eight commercial species. Overall, production of the juveniles of the 12 species within seagrass habitat (1.824 g m<sup>-2</sup> yr<sup>-1</sup>) was approximately double that of unvegetated habitat (0.940 g m<sup>-2</sup> yr<sup>-1</sup>). The seagrass production enhancement in 7 of 12 species varied from 1.8 to 169-fold. The annual production of the single cohorts of the 12 commercial species in the whole lagoon was 20,569 kg, with vegetated habitat, which covers an area 5-fold smaller than unvegetated habitat, accounting for 27.1%. Estimated total lifetime economic values of the single cohorts of the 12 commercial species were between 30 million and 59 million euros (EUR), with an exceptionally strong year class of the European seabass (*Dicentrarchus labrax*) accounting for approximately 80%, leading to higher overall values per hectare for unvegetated habitat (Low M: 32,844 EUR ha<sup>-1</sup>; High M: 16,751 EUR ha<sup>-1</sup>) than for vegetated habitat (Low M: 22,028 EUR ha<sup>-1</sup>; High M: 10,700 EUR ha<sup>-1</sup>). These results highlight the enormous importance of the Ria Formosa lagoon and in particular of its seagrass habitat as a nursery and source of recruits to coastal fisheries.



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#### Electronic waste: a round trip

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Minerals necessary to meet the electronic demands of the first world as well as those necessary to meet zero carbon emissions come from the African mines. In addition, the first world sends its electronic waste back to the African continent. This circle may not be perfect and the resulting heavy metal pollution may reach citizens in other regions of the world through seafood caught in African waters, which would act as a vector. What happens if we analyze the heavy metal content from the African continent? Is its content in heavy metals higher? The answer is yes. Higher concentrations of metals are found in species caught in African waters. In addition, correlations are found between the metal profiles between the fish caught and the waters in which they have been caught, impacted by mines and electronic waste.



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### Bumpy shrimp & we should care

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Small-scale fisheries play a substantial role in the global fisheries sector and in coastal communities, by providing halves of the world's catches and employing 90% of the fishers. However, fisheries are often threatened by the risk of overfishing, which compromises their long-term sustainability. In order to balance two divergent needs – maintaining small-scale fisheries profitable while avoiding stock collapses – it is necessary to implement the correct fisheries management measures. These must account for several elements that might affect the target species' population size, such as the environment, human activities (e.g., offshore construction, shipping), and interaction with other organisms (e.g., food availability, predation, parasitism). Thus, ecosystem-based approach to management (EBM) has been taking hold, with the aim of incorporating the entire ecosystem, including humans, into resource management decisions.

However, although parasites are a fundamental part of the ecosystem, they have not received much consideration in fisheries science, except for their use as natural tags. Identifying how parasites can impact fisheries might reduce uncertainty related to stock assessment and fisheries yield. To address this knowledge gap, we have been trying to identify all the ways with which parasites can affect fisheries, in particular small-scale fisheries, by using the Irish shrimp fishery as a model system. Its target species is the shrimp *Palaemon serratus*, a valuable shellfish which is often found to be infected by the parasite *Bopyrus squillarum*, an isopod that appears to sterilize shrimp and which creates a lateral swell on the shrimp's carapace. Hence, we have investigated the influence of this parasite on shrimp's recruitment, survival, catchability, and metabolism. The results of our research indicate that parasites have a variety of effects on fisheries, which should be accounted for in fisheries management, while our findings might be helpful to manage fisheries affected by high prevalence of bopyrid, or similar, parasites.



#### **Emerging pollutants in *Merluccius merluccius* preys. implications for resource conservation**

*Paula Cabanilles<sup>1</sup>, Alba Arduña<sup>1</sup>, Andrés Arias<sup>2</sup>, Paula Mañá<sup>1</sup>, Eva García-Vázquez<sup>1</sup>*

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There is a growing concern about microplastics (MPs) pollution due to its increasing presence in natural ecosystems and especially in the marine realm. Discovery of these particles inside marine organisms is indicative of their threatening ubiquity. Although trophic transfer of MPs has been demonstrated under laboratory conditions, there is little knowledge about this phenomenon in the wild. Their presence has also been reported in organs outside the gastrointestinal tract (GIT), meaning that the smallest particles are able to pass through intestinal membranes, reaching other tissues like the liver and to attach directly from the environment, as in the case of gills. Here, MPs along a three-link food chain (Northern krill – blue whiting – hake) were quantified, and MPs content compared between GIT, gills and liver of three hakes caught in the coast of Gijón (Spain). MPs were found in all the analysed organisms, with no evidence of biomagnification. The most common items were black and blue fibres. MPs were found in all tissues, confirming direct pollution from the environment in gills and the translocation from the GIT to the liver. MPs may items had the lowest condition factor. In view of this, plastic pollution may affect pose a threat to marine wildlife since the individual with the highest number of human health through seafood consumption, and also cause social and economic impacts on account of the ecosystem disturbances possibly altering the food web.



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## **Marine species eDNA monitoring using semi-automated samplers at the SmartBay observatory in Galway Bay, Ireland**

*Sara Fernández, Dulaney Miller & Luca Mirimin*

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Marine biological resources are under increasing demand that makes their monitoring crucial. The existence of marine infrastructures (such as cabled observatories) to monitor changes in the environment, from biological to physico-chemical parameters, offers unprecedented advantages that can boost our understanding of marine ecosystems functioning. Cabled observatories normally include a wide range of sensors, including continuous video imaging paired with physical and chemical data recorders. The inclusion of automated samplers that periodically filter seawater to facilitate the usage of environmental DNA tools provides a noninvasive technique that would improve the monitoring of many organisms. Microalgae species causing Harmful Algal Blooms (HABs) or Non-Indigenous Species (NIS), whose monitoring is a key factor in maintaining local biodiversity, environmental status, and mitigating impacts to industrial and recreational activities, can be continuously temporally monitored with minimal effort. The SmartBay observatory in Galway, Ireland is one of the test-site nodes of the European Multidisciplinary Seafloor and water column Observatory (EMSO), a European Research Infrastructure Consortium (ERIC) of distributed facilities deployed at key sites around Europe. Observatory location in Galway Bay Special Area of Conservation (SAC) gives the opportunity of incorporating novel techniques in environmental monitoring of protected areas. Here, we have applied different molecular markers in water samples collected over a time series at the SmartBay observatory to characterize the local community and detect non-indigenous or potentially harmful organisms. The results found showed community changes between seasons and allowed the detection of two NIS species (*Chaetoceros* cf. *lorenzianus* and *Chaetoceros thronsenii*) and six microalgae species potentially causing HABs. The incorporation of eDNA-based technologies to the study of marine resources would improve the biodiversity characterization of key sites and make us capable of detecting the introduction of harmful and non-indigenous species that could affect native populations, aquaculture, and fishing.



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### High levels of substitutions in the commercialization of the appreciated variegated scallop in northern Spain. Implications for sustainability

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Food fraud involves both financial and health problems for consumers as well as conservation problems for target species worldwide. In Spain, the common name “zamburiña”, which officially only refers to the species *Mimachlamys varia* (the variegated scallop), is frequently mistakenly used to refer to other pectinid species, and this confuses consumers. In this study, we carried out the first assessment of the levels of fraud in samples from 12 supermarkets/small shops offering fresh, frozen, or canned pectinid products and in 20 restaurants offering “zamburiñas” in Asturias (northern Spain). Taxonomic and genetic identifications of the involved species (using 16S mitochondrial rRNA partial fragments) were conducted. Our results showed that 73 (49%) out of the 148 analyzed samples from the fifteen commercial products under study (4 fresh, 6 frozen and 5 canned products) were mislabeled (a global 60% of commercial products had substitutions). Moreover, the analysis of the dishes that were commercially labeled with the vernacular name “zamburiñas” from 20 restaurants sampled across the region revealed that in all of them (100%), the species detected was the Peruvian scallop (*Argopecten purpuratus*), known in Spanish as “vieira del Pacífico”. These results imply intentional deceit and therefore violations of consumer rights. Moreover, this might result in economic damage and serious problems for correct marine resource management and exploitation plans.



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### Genetic studies using mitochondrial DNA for the sustainable octopus fishery in northern Spain

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\*Both authors contributed equally to this study.

*Octopus vulgaris* is one of the most harvested octopus species in the world. In the Iberian Peninsula, northern Spain, there are several small-scale fisheries that have a long-time tradition of harvesting this species, with the Asturias fleet owning an internationally recognized MSC label for its exploitation. Concernedly, these octopus fisheries lack any genetic assessments of the exploited stocks, which prevents the implementation of adequate managing strategies. In this study, we attempted to analyze, using two mitochondrial markers (the cytochrome oxidase subunit 1 and the control region), the genetic status and evolutionary events that conditioned octopus populations' characteristics in the northeastern Atlantic. A total of 90 individuals were sampled from three different localities in the Iberian Peninsula and another location in the Macaronesia. Additionally, temporal genetic analysis on Asturias and Algarve populations were also performed. Overall, results reported an absence of a fine spatial genetic structuring but showed Canary Island as the most distinct population. The phylogenetic and phylogeographic analyses revealed two distinct clades ( $\alpha$  and  $\beta$ ) but for the first time, we confirmed the presence of the  $\alpha$  southern haplogroup in the northern Iberian Peninsula. This result, contrary on what has been previously hypothesized about a single glacial refugee for *O. vulgaris* at northern Africa, suggests additional potential refugia for the species in northern latitudes. Moreover, our results would indicate a more continuous cline for the distribution of these two haplogroups than previously reported. The use of mitDNA is not too much useful to infer consequences of fishing effort and the status of the octopus stocks at shorter and contemporary scales. However, it has been indeed useful to discard species crypticisms and to estimate past and present distribution patterns of the species helping to further clarify the evolutionary origin and conservation units for the high valuable *O. vulgaris* species.



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### **Virgin polystyrene microparticles exposure leads to changes in gills DNA and physical condition in the Mediterranean mussel *Mytilus galloprovincialis***

*Paula Massia, Eva García-Vázquez & Alba Ardura*

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Microplastic concentration in marine environments has been exponentially increasing during the last decades and will continue. Due to the harmful consequences that plastics can have on marine biota, the future health status of marine species is still unknown. In the present study, the commercial species *Mytilus galloprovincialis* was exposed to 21 daily doses of polystyrene microparticles (10 µm) at four different concentrations (control: no microplastics, C1: 0.02 mg/L, C2: 0.2 mg/L, and C3: 2 mg/L). Health status was measured through the condition index for the physical condition, and through DNA fragmentation for damages in gills DNA. Results indicate that under higher doses mussels showed a worse physical status; however, under the same concentrations, DNA integrity showed a minor damage. Therefore, these results may indicate that when mussels are exposed to high microplastic concentrations, a decrease in their feeding activity/filtration rates is produced, thus reducing the direct exposure to microplastics in gills. Further investigations should be done in order to determine if commercial species may suppose a risk for human consumption; as well as to assess the health status of marine organisms in a near future.



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## **Microplastics in the European eel (*Anguilla anguilla*): from Sargasso Sea to the Asturian rivers**

*Daniel Menéndez, Eva García-Vázquez & Alba Arđura*

*Department of Functional Biology, Genetics, University of Oviedo, C/ Julián Clavería s/n, 33006, Oviedo, Spain.*

The critically endangered European eel is a catadromous organism whose individuals are born in the Sargasso Sea, in the western Atlantic Ocean, and travel to European rivers to grow in freshwater. In addition to the damage caused by environmental pollutants on organisms, they can act as a vector for them. The purpose of this work is to analyse the presence of microplastics (MP) in eels and determine the origin of them. For that, the amount and composition of microplastics transported by the European eel in three different river mouths in the Asturian coast were analysed, as well as their presence in freshwater, sediments, and seawater from the same areas. From the 836 particles reported, 97% were fibers. For the composition, 34% of the items analysed were plastics, being the 49% human-modified cellulose. Besides, plastic fragments were found in the muscle near the surface of the animal in two specimens, corresponding to alkyd urethane, a type of polyester resin and concluding their incorporation during the developmental stages. Although further analyses are necessary, this work presents for the first time the presence of MP in eels, highlighting its presence even from the beginning of their development stages and the greater influence of rivers on this pollution.



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### Analysis of microplastics on the Asturian coast: composition and effects

*Susana Aclé<sup>1</sup>, Eva García-Vázquez<sup>2</sup> & Alba Ardura<sup>2</sup>*

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Marine litter, and in particular plastics and microplastics, affect the entire ocean and its inhabitants. They have become part of the food chain, and are a serious challenge, to meet the goals of sustainable global fisheries. Addressing this global threat, is a complicated challenge, but absolutely necessary if we are aware of the need to maintain a healthy environment, and keep in mind our social responsibility as a human species. It is interesting to face this global challenge from a local perspective. "A lot of small people, in small places, doing small things, can change the world." (Phrase by Eduardo Galeano).

This study presents the results of a sampling carried out in the Cantabrian Sea. 49 samples of 5 liters of water were filtered, analyzed under the microscope and sent the material to be analyzed using the F-TIR technique. The final results obtained, have been evaluated by the ECHA (European Chemical Agency), and are presented on a map of the Asturian coast which includes: the collection points of the water samples, the results of microplastics detected, the analyzes obtained from them by the F-TIR technology and the ECHA assessment of these.

This assessment presents certain products with different degrees of toxicity, which pose a risk and that it is undoubtedly necessary to assess and control to meet the objectives that sustainable fishing requires.



#### **Structure of fish assemblages in an equatorial estuarine mangrove ecosystem, the Akanda National Park (Gabon)**

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Mangroves ecosystem are among the most productive tropical and subtropical coastal forest ecosystems in the world. Their function in supporting the renewal of fish stocks is well documented. However, in Central Africa, specifically in Gabon, few scientific studies on the ichthyofaunal biodiversity of mangrove ecosystems have been carried out. Numerous protected areas including mangroves, notably the Akanda National Park, have been created and used as strategic tools to preserve the renewal of fish populations exploited by fishing in Gabon. The purpose of this study is to draw up an inventory of the different fish species in the Akanda Park and to study ichthyofaunal community organisation. With a surface area of about 53.780 hectares, the Akanda Park is located between the Libreville peninsula and Equatorial Guinea. Ichthyofauna was collected using trammel gillnets during the four main hydro-climatic seasons of the region: High Rainy Season, High Dry Season, Low Rainy Season and Low Dry Season. The results reveal the presence of 59 fish species belonging to 30 families. The best-represented family is the Clupeidae family with 5 species. The most abundant species is *Pseudotolithus elongatus* (18% of the total abundance). From a biomass point of view, *Pseudotolithus elongatus* (24% of the total biomass) is in first place followed by *Chrysoschthys nigrodigitatus* (21%) and *Plectorhinchus macrolepis* (11%). The size spectrum reveals a fish assemblage dominated by small size individuals. The Shannon index and equitability justify the absence of strongly dominant species. The evolution of the depletion curve reflects an increase in species richness as a function of sampling effort. Estuarine species of marine origin and Marine-estuarine species, first level predators mainly benthophagous and second level generalist predators mainly feeding on fish, shrimps and crabs are the most present, whatever the season and the site.



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## **Education for Sustainable Consumption: needs and game-based learning activities on marine fisheries in Primary education**

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The Ecosifood questionnaire on evaluation of attitudes and impacts produced by fish ecolabels in the consumers was used to assess perceptions and use of fish labels information, to choose sustainable fish options, by students of a postgraduate teacher training course on research and innovation in early childhood and primary education. Results shown that postgraduate teachers perceptions on fish ecolabels, including environmental and social values of sustainable fisheries, are positives. However, most of them do not read the labels information in fishmongers and supermarkets before making their purchases, therefore not knowing whether they consume fish from sustainable fisheries or its procedence.

With the aim to provide teacher resources on sustainable fisheries for these Primary education teachers, game-based learning activities and resources linking environmental education, education for sustainable consumption and knowledge about small-scale fisheries of Asturias were design. This way, the activity Fishing for hits was designed including several independent task in the form of learning games (alphabet games, getting the concept, question games), each one aimed at learning different characteristics of marine biodiversity, marine natural resources collected in small-scale fisheries, the chain of consumption that goes from fishing boats to the purchase of fish by the consumer and the possible content of eco-labels.



#### **Understanding spatial behaviour of commercial fishing boats foraging around fishing aggregating devices in the southern Philippines**

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The extensive and unregulated use of fishing aggregating devices (FADs) in the Philippines is considered one of the main threats to the tuna fish stock in that region. These artificial floating structures, that efficiently accumulate fish biomass beneath them, are accused of increasing the bycatch of juvenile tuna and other endangered species. Currently, there is a lack of information based on satellite data regarding the use of fishing aggregating devices in Philippine waters.

Using global positioning system devices and logbooks, this study tracked seven commercial fishing boats from two sites in the Southern Philippines over the course of a year. By using the geographic positions of the boats and the reported FADs, some variables were created by the means of a geographic information system. Using these variables, information was provided about the spatial behaviour of these vessels, and the best variables to predict the distance of boats from FADs are selected through correlation analysis and linear regression models.

The results indicate that these boats forage in patches, relatively distant from the coast, staying long periods in the fishing grounds searching for schools of pelagic fishes. It sustains the observed trend in the Philippines of purse seines migrating to offshore waters aiming greater catches. The best variables selected to predict the distance to a fishing aggregating device, which can be a proxy of the fishing behaviour in this system, are the step length and polygons drawn based on the movements of the boats. Assisted by the commonly used speed, the combination of these other variables might be useful to distinguish the fishing from non-fishing behaviour in systems where the boats stay for long periods in the ocean. This represents a reliable and cost-efficient way to estimate the fishing effort, which is an essential parameter to manage fish stock.



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## **Help the kelp - protecting an important habitat for commercial fish species in warming oceans**

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Kelp forests around the world are important biodiversity hotspots. As bioengineering species those macroalgae create sheltered habitat for a large diversity of species such as many commercially important fish species. Not only do they provide a food source for marine species but many macroalgae species are harvested as highly nutritious products for human consumption as well. The market for kelp based products is growing fast. However, increasing stress of warming waters and heat wave events disturb their resilience and fertility causing major deforestation events around the world. A solution for the protection and reforestation of kelp forests could be to focus restoration efforts on more heat resistant macroalgae species. This study created a phylogeny of macroalgae with the Heat Shock Protein 70, looking at their geographical distribution and proposing more heat resilient species for reforestation to save our kelp forests. Thereby not only ensuring a growing market for kelp products but also protecting an important habitat for commercial fish species.



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Challenges and  
opportunities for  
sustainable fishing  
in a changing  
world.



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### Is the stalked barnacles fishery in Asturias sustainable? Results from a field experiment

*Katja Geiger, Julio Arrontes, Consolación Fernández, Jose Manuel Álvarez, Jorge Álvarez & Jose Luis Acuña*

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Stalked barnacles (*Pollicipes pollicipes*) reach high market prices and are intensively harvested on the Iberian Peninsula. In Asturias (North Spain), the stalked barnacle fishery is an important component of the small-scale fisheries. Since the beginning of the professional harvest in 1994, a co-management system was implemented which was thought to enable the sustainability of the system, but no in-depth study has yet confirmed this. To study the sustainability of the current stalked barnacle harvest intensity and the impacts on the intertidal community, a field experiment was conducted. Different treatments were applied to 36X36 cm surfaces in three different sites along the East coast of Asturias from July 2017 until July 2019. Treatments combined scientific harvest (with and without harvest) and harvester exclusion (with and without protective cages). Uncovered surfaces exposed to the harvest by professionals showed a declining trend in the area occupied by *P. pollicipes*. This suggests that the current harvest intensity by professional harvesters might not be sustainable. However, net surface gain in harvest exclusion cages more than compensates the losses in harvested cages. This indicates that the practice of one year bans in co-managed Asturian fisheries is effective in the recovery of populations. Analysis of the biodiversity indicates that recovery of exploited patches is a slow process involving intermediate colonization by earlier successional species, explaining the common perception that the rocks are being invaded by species other than stalked barnacles in overexploited areas.



#### **Analysis of ocle (*Gelidium corneum*) extraction along the Asturian coast and its influence on the sustainability of the resource**

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The exploitation of ocle (*Gelidium corneum*) along the Asturian coast has an important economic and cultural component. Through the extraction methods of hand plucking underwater and collection of cast seaweed, the ocle contributes to the livelihoods of many individuals within the region. This species is an international commodity harvested for the production of agar and agarose. The aim of this study was to examine the sustainability of *Gelidium corneum* hand plucking by comparing natural standing biomass with exploited biomass using landings and biomass data available from the Centro de Experimentación Pesquera in Asturias.

In order to assess the effect of exploitation on ocle biomass along the Asturian coastline, three research questions were posed. Firstly, the change in ocle biomass along the coast during the years 1987-2021 was examined in exploited and non-exploited sectors. It was hypothesized that over time, if unsustainable, exploited sectors would show a decrease in total biomass compared to non-exploited sectors. Secondly, the change in ocle biomass due to summer extraction was assessed. It was hypothesized that the summer ocle harvest would negatively affect the following quarters' biomass. Thirdly, the change in sea surface temperature (SST) during the sampling period was compared against ocle biomass changes. It was hypothesized that increased SST, as a proxy for environmental change, could have an effect separated from exploitation. The results illustrate the maintenance of the resource in exploited populations, and suggest that the strength and method of exploitation of ocle affects its biomass and distribution along the Asturian coastline. In order to accurately assess the sustainability of extractive methods, targeted study and management plans regarding each technique are recommended.



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### Revising ecolabels using genetic tools: the common octopus (*O. vulgaris*) case study in the southern area of the Bay of Biscay

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*Octopus vulgaris* is a cephalopod species with great economic value. In Asturias (north of Spain), *O. vulgaris* artisanal fisheries are relatively well monitored and conditionally eco-labeled. Despite the huge market power of this species, Asturian *O. vulgaris* stock has not been genetically assessed so far. For improving the current fishery plan and ensure the label validity in Asturias, 308 individuals from 5 different locations were collected and genotyped at thirteen microsatellite loci to study the levels of spatial and temporal genetic variation among stocks and identify specific management units for *O. vulgaris* populations along the eastern coast of North Atlantic. Spatial levels of genetic differentiation were estimated using F-statistics, multidimensional scaling and Bayesian analyses. Results indicated that the *O. vulgaris* stocks consist of five genetically different populations. All of them were in Hardy-Weinberg equilibrium with no evidence of recent bottlenecks. In addition, temporal analyses showed high  $N_e$ 's and genetic stability in 9 generations. Even though Asturias fishery plan has shown no current significant damages to stocks, the regional specific management may need implementation of smaller schemes since genetic heterogeneity was found within Asturias. Findings from this pioneering research are the basis for further genetic studies and subsequent sustainable fishery schemes.



#### **Mislabelling on board. High levels of mislabelling and their implications for sustainability in black hake fisheries**

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A correct reporting of catches is the first step towards a good management of stocks and therefore, essential for fisheries sustainability. However, the accuracy of these identifications can become a challenge for morphologically similar species. This is the case of two species of the genus *Merluccius* caught together in the mixed fisheries of the Central East Atlantic: *Merluccius polli* and *M. senegalensis* are both fished under the umbrella term of “Black Hakes”. While they are currently managed as a single stock, differences in their biology and relative abundance point towards a better management as separate stocks. For this study, 806 samples of hakes (labelled as *M. polli* and labelled as *M. senegalensis*) were identified both visually by fishermen on board and through the use of DNA barcoding in order to test the composition and reliability of the catches. The comparison between both identifications revealed high levels of mislabelling (31.4% of samples were misidentified) and showed underreporting of *M. senegalensis*. This may be of special concern for these species given their current declining populations and its status as an endangered species. Furthermore, visual identifications showed a bias linking the mislabelling to depth of captures and on hake sizes, as larger individuals caught from deeper waters were more likely to be assigned correctly as *M. polli* and those shorter or caught at shallower depths are more often mislabelled. Overall, the high mislabelling detected manifest the need of establishing DNA barcoding as a surveying method that can guarantee the accuracy of species identification in mixed fisheries.



#### **Spatio-temporal genetic heterogeneity in the highly valued *P. pollicipes*: implications for sustainable fisheries management**

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The stalked barnacle *Pollicipes pollicipes* inhabits rocky shores from the Atlantic coasts Brittany (France) to Senegal. Because of the culinary traditions of southern Europe, stalked barnacles represent an important target species for local fisheries on the Iberian Peninsula. To manage this fishery sustainably, it is therefore important to assess the dynamics of local populations over the Iberian coast, and how they are interconnected at a wider scale using finely tuned genetic markers. In this work, twenty polymorphic loci arranged in five multiplex PCRs were then tested and validated as new molecular tools to address the spatial and temporal genetic patterns of *P. pollicipes* from the Atlantic Iberian coast. Our results revealed high genetic diversity among adults. However, juveniles were genetically more structured than their adult counterparts, which alternatively displayed much more connectivity among the three studied regions. The lack of spatial genetic heterogeneity in adults may be due to the superimposition of several generations of settlers coming from different geographic origins, which mainly depends on the orientation of residual currents along the coast during reproduction. The genetic differentiation of juveniles may indeed be congruent with Iberian Peninsula hydrodynamics, which can produce chaotic genetic patchiness at small temporal scales due to sweepstake reproductive success, collective dispersal and/or self-recruitment. Remarkably, most of the genetic heterogeneity of juveniles found in this work was located in Galicia, which could represent an admixture between distinct metapopulations or an old refuge for most northern populations. To conclude, high genetic variation in *P. pollicipes* can lead to the false impression of population panmixia at the Iberian scale by masking more restricted and current-driven larval exchanges between regions. This possibility should be taken into consideration for further specific management and conservation plans for the species over the Iberian Peninsula.



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# *Social challenges in sustainable management*



#### **Assessment of economic net value and carbon emissions of small-scale fleets in the EU Atlantic fishing grounds. An ecosystem services and spatial approach**

*Laura García-de-la-Fuente<sup>1</sup>, Claudia Suárez-Arbesu<sup>1</sup>, Arantza Murillas<sup>2</sup>, Estanis Mugerza<sup>2</sup>, David Castilla-Espino<sup>3</sup>, Juan J. García-del-Hoyo<sup>3</sup>, Adam Kennerley<sup>4</sup>, Ana Ribeiro-Santos<sup>4</sup>, Angela Muench<sup>4</sup>, Tania Mendos<sup>5</sup>, Richard Curtir<sup>6</sup>, Pedro Pintassilgo<sup>7</sup>, Mafalda Rangel<sup>7</sup>, Inês Sousa<sup>7</sup>, Nuno S Henriques<sup>7</sup>, Jorge M.S. Gonçalves<sup>7</sup>, Christophe Macabiau<sup>8</sup> & Sebastien Demanèche<sup>9</sup>*

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Small-scale and artisanal fisheries (SSF) provide one of the most important ecosystem service (food supply) of the seas worldwide; but, even in the European Atlantic context, SSF still lack detailed socioeconomic information, an ecosystem-based management and spatial knowledge. The aim is to provide new spatial and temporal knowledge on the economic performance of fish provisioning ecosystem services linked to SSF in the Atlantic Area, their contribution to carbon emissions and eco-efficiency levels of these fleets (2012 – 2016).

Data from the Annual Economic Report of the European fishing fleet have been used to preliminary quantify, map and evaluate provisioning ecosystem service, its evolution over time, and comparison between Atlantic countries, ICES fishing grounds and main gears.

Results show that the added value generated by the artisanal fishing fleets in the Atlantic Area is large compared to the rest of the EU (30%), although important differences do exist between fishing gears, regions, and vessels' length. EU Atlantic carbon emissions trend remains relatively unchanged over time, with an only increase of around 3% in five years. Particular results for the Cantabrian and Northwestern fishing ground (ICES 27.8.c) show that it is one of the most efficient fishing area: it is the fifth area with the greatest contribution to the total VA at the Atlantic Area (58 million euros in 2016), the second one with the highest GVA per fishing day (46,000 euros in 2016), and the most eco-efficient one (1.71 tCO<sub>2</sub>/tkg). In terms of the volume of emissions of CO<sub>2</sub> generated by this fishing ground, the study period (2012-2016) has remained relatively constant.

This first assessment will seek to achieve greater spatial detail, and to consider interactions between this service and other marine regulating ecosystem services to detect cross-impacts and trade-offs in the Atlantic fishing grounds.



#### **Economic approach to sustainability branding: the case of octopus catches by asturian western fishermen**

*José Alba & Inés Álvarez-Vega.*

*Department of Applied Economics, University of Oviedo, Spain*

The octopus represents an interesting resource for restoration and other purposes in several countries. Asturias and the neighbour autonomous community of Galicia have strong traditional consumption of this marine specie. This is the root of the wide supply of culinary specialities for tourists and incountry population, even for the direct consumption at home.

The management of the octopus population is being studied and oriented trough an interesting initiative of cooperation. It involves both the sea workers, asturian administration, associations and university researchers, to name a few.

As a result of the definition of the sustainable development aim, drawn on a compromise to produce proper captures, a sustainable mark is being used. The opportunity to link the traditional sustainable fishing of octopus way to MSC accreditation provide fishermen with the possibility to take profit from their very special attitude and knowledge around octopus catches.

After a field work concentrated around Puerto de Vega and Luarca, but extended from Llanes to Tazones, Avilés, Vegadeo and even the Galician region (Ribadeo) we detected an increasing in the prices paid to sustainable producers for the last few years. In addition to this, the social profit of mantaining the activity includes touristic and educational spills.

The demonstration of the coincidence between the private and public interest constitutes a challenge in order to promote other initiatives in the whole area. Then, a stakeholder adaptation to emerging social targets and promotion of new sustainable models would be supported on concrete experiences such as this one. Moreover, the cooperation with NGO would state the proper compliance of common desires.



#### Small-scale fisheries and cultural ecosystem services in the EU Atlantic Area. A first inventory and analysis of cultural heritage

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Cultural services are one of the major types of services generated by marine and coastal ecosystems, with artisanal and small-scale fisheries (SSF) historically standing out as a source of maritime cultural heritage worldwide. The main objective of this study is to gather, identify and classify European Atlantic cultural heritage linked to SSF, providing local communities with a new tool to promote a blue growth focused on a sustainable fishing culture, SSF diversification and tourism.

To this end, different sources have been explored to gather citations, references, materials and information of a vast array of cultural and natural heritage elements of SSF in five countries. This collection has been classified according to the cultural heritage classification of UNESCO. A cluster and factor analysis of the elements in this database has been also carried out.

A total of 1566 elements have been collected: 83 representing natural heritage, 332 immobile and 64 mobile tangible heritage, 1,087 intangible cultural heritage. The categories "Traditional craftsmanship" and "Knowledge and practices concerning nature" include most of the elements. At country level, Spain stands out above the rest of the countries, with approximately 53% of the total items included in the inventory, followed by Portugal and Ireland, with 18% and 16% respectively. At regional scale, 209 elements in the database refer to the Asturian SSS cultural and natural heritage. It should also be noted that many of them may also belong to several UNESCO's categories. Results show the existence of five independent factors from the eleven variables that represent the different types of cultural heritage. Regarding the cluster analysis, five different clusters have been identified.

Although this inventory is preliminar and potentially expandable, it shows the richness of this cultural ecosystem service in the Atlantic Area and the potential for their future economic use and management.



#### **Childhood education preservice teachers' knowledge and perceptions on sustainable fisheries and seafood**

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Sustainable fisheries are needed to achieve the Sustainable Development Goal 14 “Conserve and sustainably use the oceans, seas and marine resources for sustainable development”. Environmental education at school can be a keystone to achieve this goal and requires to include (biodiversity) knowledge about marine species collected and to develop an education for responsible consumption since early years.

A didactic sequence to allow that early childhood education preservice teachers thinking about sustainability of fisheries and learn on fish and seafood fished and consumed in Asturias was implemented. A diagnostic questionnaire and dialogic sessions on Asturian small-scale fisheries, labelling and identification of fish, enumeration and identification of collected fish, molluscs and crustaceans was design.

Preservice teachers expressed doubts about the situation of small-scale fisheries in Asturias. They considered that most of the fishing boats and jobs depended on artisanal fisheries, and that these fisheries were carried out near the coast, but they were not clear which species are included in artisanal fisheries or what happened in fisheries on the high seas. The teachers listed between 1 and 8 species of fish, 0-8 of molluscs and 1-7 of crustaceans collected for human consumption. They trust that the labelling of seafoods allows to know its origin, and they kwon that seafood available in fishmongers and local restaurants can come from different areas, although they don't kwon whether the seafood obtained by small-scale fisheries could be consumed far from the fishing towns. Preservice teachers are aware of their limitations to identifying the most common fish on the food, fishmongers or in the sea. Between a third and a half of the students correctly identified relatively common species (gilt-head bream, sea bass, cockle, anchovy, four-spot megrim...), with lower results for live specimens than those photographed in fishmongers.



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