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INTEGRATED ECOSYSTEM ASSESSMENTS STEERING GROUP

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Interim Report of the Working Group on Comparative Analyses between European Atlantic and Mediterranean marine ecosystems to move towards an Ecosystem-based Approach to Fisheries (WGCOMEDA)

29-31 May 2018

Sète, France

ICES International Council for the Exploration of the Sea
CIEM Conseil International pour l'Exploration de la Mer

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Executive summary

The ICES Working Group on comparative analyses between European Atlantic and Mediterranean Ecosystems to move towards an Ecosystem-based Approach to Fisheries (WGCOMEDA) is now in the second year of its second three-year cycle, having consolidated its collaborative platform. WGCOMEDA was established in 2014 and works in cooperation with other groups within the ICES Integrated Ecosystem Assessments Steering Group (IEASG). The group (chaired by Manuel Hidalgo, Hilmar Hinz and Marta Coll from Spain, and Christian Möllmann from Germany) met for the fifth time in Sète, France, on 29–31 May 2018. 12 scientists from European Atlantic and Mediterranean countries attended the meeting (Germany, France, Greece, Spain, Sweden, and European Commission).

The objectives in the meeting were: i) to set the analytical and data framework to develop common Integrated Ecosystem Assessments (IEA) exercises, ii) to advance in several ongoing comparative studies on ecosystems stability, and iii) to frame comparative size- and traits-based approaches in both demersal and benthic ecosystems. To do that, the group focused in the following topics, which combined activities initiated during last years with new studies and tasks.

1. **Common Integrated Ecosystem Approach exercise across regional systems of the Atlantic Ocean and the Mediterranean Sea.** The group discussed pros and cons of the main IEA methods to be applied, the preliminary results on a subset of regional systems, and set the common framework to conduct an integrated trend analysis of Atlantic and Mediterranean fish communities with the goal to identify the importance of global climate drivers vs. regional oceanographic variables.
2. **Interplay between stability-diversity-resilience: embracing temporal and spatial scales.** The discussion of the group was based on results of recent analyses applied to assess the spatial stability. The group also discussed how these new results can be linked large-scale assessment on temporal stability of fish communities previously developed within the Expert Group (EG).
3. **Worldwide assessment of stability in pelagic ecosystems.** Final set of analyses on the stability of pelagic fish communities' worldwide were presented as well as potential drivers and stressors.
4. **Interplay between taxonomic and structural (size-based) stability across contrasting systems.** The group looked at final set of results that corroborated in which circumstances structural stability based on the size spectra of fish community contributes to stabilize fish communities with different levels of diversity.
5. **Novel methodologies to asses Benthic Habitats Sensitive to bottom trawling:** developing comparative analyses and implementation of life-history traits and size information. Discussion of the group focused on how information of species life-history traits and physical environment can synthesize information of the disturbance and the populations' scope to grow resulting on Benthic Habitats Sensitive indices to bottom trawling.
6. **Traits-based approaches (TBA) on affected ecosystems:** Several comparative approaches were presented to move forward from previous TBA developed within WGCOMEDA and others EGs of IEASG. The group discussion focused on two elements: i) quantitative distribution of traits in different habitat types and across environmental variables and, ii) temporal changes in traits composition and how would be the best way to determine them.

The group decided to meet by the end of May 2019 in Palma de Mallorca (Spain) or in Ispra (Italy) (final hosting location pending of confirmation).

1 Administrative details

Working Group name

Working Group on Comparative Analyses between European Atlantic and Mediterranean marine ecosystems to move towards an Ecosystem-based Approach to Fisheries (WGCOMEDA)

Year of Appointment

2016

Reporting year within current cycle

2

Chairs

Manuel Hidalgo, Spain

Christian Möllmann, Germany

Hilmar Hinz, Spain

Marta Coll, Spain

Meeting venue

MARBEC MARine Biodiversity, Exploitation and Conservation, Sète, France

Meeting dates

29–31 May 2018

Participants group photo of the WGCOMEDA meeting in the MARBEC unit in Sète, France. From the left to the right: M. Hidalgo, J. Otero, P. Vasilakopoulos, B. Merigot, E. Zanatos, M. Casini, R. Frelat, S. Vaz, T. Hattab and Luís Outeiro (Elliot Sivel does not appear in the photo).

2 Terms of Reference a) – d)

ToR	Description	Background	Science Plan topics addressed	Duration	Expected Deliverables
a	Provide a more complete understanding of the structural and functional role of ecological stability across different types of ecosystems.	a) The scientific and applied development of this ToR is sustained by the all the outcomes obtained in the previous 3-years of WG, that evidence which are the strategic and needed lines to follow up the research on this topic, and combining information from both seas (Atlantic and Mediterranean). b) The ecological and applied importance of understanding the mechanisms affecting the stability of natural systems for IAF justifies the work and research to be developed in this ToR. c) The ToR will benefit from the attendance of scientists from other WGs from IEASG such as WGIAB or WGEAWESS, and the designed back-to-back meetings with WGIAB and WGEAWESS. This guarantees a good coordination with other WGs of IEASG.	1 and 3	3	Scientific collaborative papers for several scientific questions: 1. The relative influence drivers and structural properties of communities for different type of ecosystems both in both seas (Atlantic and Mediterranean). 2. The relative contribution of different functional groups to the stability of different systems. 3. Mechanisms affecting the non-stationary pattern on stability. 4. Relationship between temporal and spatial stability. 5. Mechanisms affecting ecological stability in the pelagic realm.
b	Use of functional traits information to assess the structure and	a) This topic is directly addressing two main themes of ICES Strategic Science plan i.e.	1 and 3	3	1. Database on demersal fish and benthic invertebrate traits for species used within the

	functioning of demersal and benthic communities across Mediterranean and Atlantic systems; and to predict their vulnerability to fishing disturbance.	EFD Ecosystem Process and Dynamics and EPI Ecosystem pressures and Impacts. The TOR will provide further insights into the development of indicator that may help with the management of ecosystem goods and services and help to devise management strategies that may help to mitigate human impacts on these. b) The TOR is direcly related to outcomes obtained in the previous 3-years of WG, where the genearl ideas and work flows have been developed. Based on these previous outcomes the current TOR aims to complete a cross Mediterranean Atlantic comparison			analyses including where possible real data from a regional scale data e.g. median size, maturity etc. 2. Methodology to assess the resistance/resilience of demersal and benthic communities with respect to their trait composition to fishing. 3. Collaborative scientific papers comparing functional properties of demersal and benthic communities across regional seas and their vulnerability to fishing disturbance.
c	Further develop the analysis of the link between ecological stability across different ecosystems types and ecosystem properties (structure and functioning)	a) The scientific development of this ToR is sustained by the outcomes from the previous 3-years of WG with the aim to follow up in the research on this topic. It will combine information from both seas (Atlantic and Mediterranean). a) This topic is addressing several main themes of ICES Strategic Science plan i.e. EFD Ecosystem Process and Dynamics and EPI Ecosystem pressures and Impacts. The TOR	1 and 3	3	1. Database on ecosystem properties of Mediterranean and Atlantic marine ecosystems 2. Methodology to assess the links between ecological stability and ecosystem properties. 3. Collaborative scientific papers comparing ecosystem stability and ecosystem properties across regional seas and their vulnerability to fishing disturbance and environmental factors.

	will provide insights into the knowledge needed to understand ecosystem dynamics that could help with guidelines needed for the management of marine resources.	

3 Summary of Work plan

Year 1	WGCOMEDA work has been designed attending to the results achieved during its first 3 years to define which research topics will continue while reshaped in the new the ToRs a,b, and c. An important element in this new cycle is the work to be developed in the ToR d that will be done in close collaboration with members of WGIAB or WGEAWESS. It aims at identifying the main elements of the work developed in progress by WGCOMEDA that may have potential implementation in ICES IEA programme. The group will focus in identifying potential to use the scientific results of WGCOMEDA in the work of the regional IEA expert groups. This will be achieved by back-2-back meetings (with WGIAB and WGEAWESS) and direct communication with chairs.
Year 2	Develop the analyses and modelling defined for each ToR. The group will use the knowledge obtained in previous research, and the new scientific objectives agreed in the discussions of the first year to develop the statistical analysis and ecological modelling required. This will be developed for each research topic agreed. During the second year, the group will start developing products derived from the scientific results of WGCOMEA for regional IEA implementation.
Year 3	Final discussion and synthesis of all the research topics The group will discuss the final results and outcome for the different research topics along the ToR a, b, c, and d. Implementation of the strategic knowledge gained in the WG into the ICES IEA programme The group will produce a document outlining the use of WGCOMEDA scientific results in the regional IEA contexts.

4 List of Outcomes and Achievements of the WG in this delivery period

- Several members of WGCOMEDA presented the work developed under the framework of the WG in the World Conference of Marine Biodiversity in May 2018, Montreal (Canada)**:**
  - **i)** Frelat *et al.*, How does diversity influence the stability of communities? and,
  - **ii)** Hinz *et al.*, Benthic vulnerability to trawling and its consequences for ecosystem functions: A traits based approach.
- A transcontinental IEA exercise has been set, including preliminary results, and a shiny application developed in R has been designed.
- S. Vaz attended the annual MEDITS meeting and presented, on behalf of the chairs, the progress of the WG and the coming activities for the next year.

5 Progress report on ToRs and workplan

The WG has successfully advanced in all the ToRs, with the exception of ToR c because the leader was not able to attend the meeting due to other commitments. At the 2018 meeting, each ToR break down in several specific topics here below expanded. Along the week, several additional talks were framed with each topic, in addition to a final talk on socio-economic issues presented as potential line of research for WGCOMEDA in the close future.

We list hereafter the different Research Topics, some of them developed under the same ToR.

5.1 TOPIC 1: Transferring methods and tools on Integrated Ecosystem Approaches (IEA) – Part of ToR A: (Lead: C. Möllmann).

Several talks were presented with in this topic on different ongoing cross-comparison exercises.

5.1.1 Setting common IEA exercises in regional systems of the Atlantic Ocean and the Mediterranean Sea (C. Möllmann)

An integrated trend analysis of Atlantic and Mediterranean fish communities has been designed with the goal to identify the importance of global climate drivers vs. regional oceanographic variables. We are especially interested in recent (last decade) changes related to multiple and cumulative drivers. In addition, a proof of text with different methods was applied in few systems to compare the results. The analysis will be based on matrices of fish abundance/biomass time-series (year X species). Initially a suite of dimension reduction techniques (Principal Component Analysis, PCA, Forecasting Component Analysis, ForeCA, Dynamic Factor Analysis, DFA, or Local Linear Embedding, LLE) will be applied to extract the main trends (i.e. dimensions) inherent in each dataset. The extracted dimensions will be used as response variables in regression analyses (GLM, GAM) identifying important external drivers. Furthermore, statistical change-point analysis and threshold regression models (TGAM) will be applied to identify potential abrupt changes indicating regime-shift dynamics. Formal meta-analytical methods will be considered as well. For systems that exhibit abrupt shifts, resilience mapping (Vasilakopolous and Marshall, 2015) will be conducted to identify hysteresis effects. A shiny app will be developed that allows for easy communication of Atlantic and Mediterranean fish community developments (Figure 5.1).

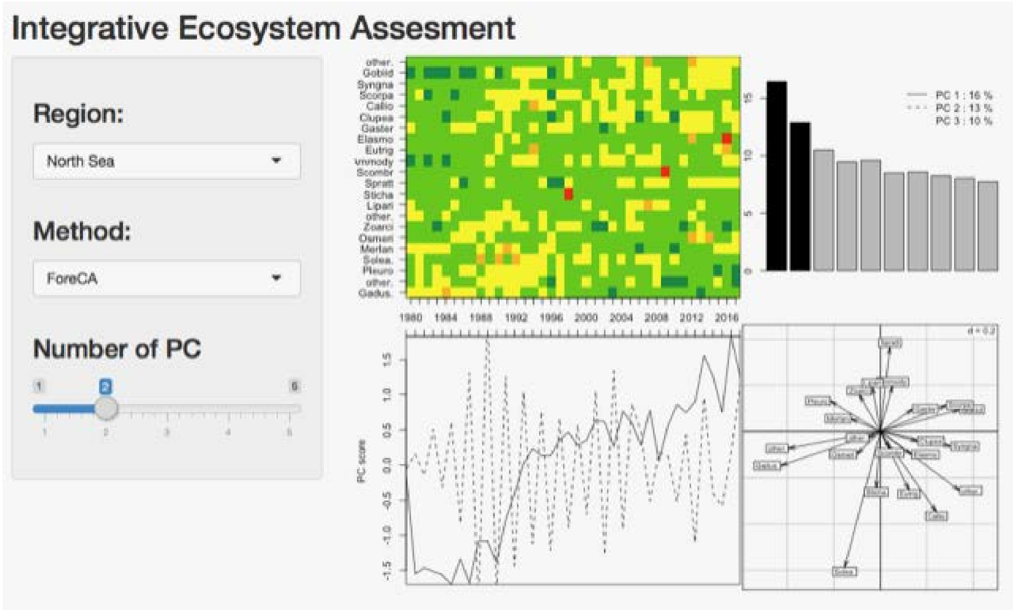

Figure 5.1. Shiny application displaying the main outputs of several methods potentially used in the framework of Integrative Ecosystem Assessment (IEA).

5.1.2 Recent Integrated Resilience Assessments (IRAs) in the NE Atlantic and the Mediterranean (Paris Vasilakopoulos)

The Integrated Resilience Assessment (IRA) is a three-step analytical process to assess resilience dynamics and construct stability landscapes of empirical complex systems (Vasilakopoulos and Marshall, 2015; Vasilakopoulos *et al.*, 2017). This process involves a multivariate analysis to estimate holistic system indicator variables, non additive modelling to estimate alternate attractors, and a quantitative resilience assessment to scale stability landscapes.

WGCOMEDA provides an excellent platform for collaboration with scientists working in different European Seas. This collaboration led to the development of IRAs for a range of different systems. Over the past year, the IRA framework was implemented in three case studies investigating in total eight different complex marine systems: two basins of the Baltic Sea (in collaboration with Christian Möllmann and Romain Frelat; Figure 6.2), four areas of the NE Atlantic (in collaboration with Marcos Llope and Thorsten Blenckner) and two areas of the western Mediterranean Sea (in collaboration with Manuel Hidalgo). In all these cases, the application of the IRA allowed elucidating the link between the multivariate development of complex systems and anthropogenic/environmental stressors, as well as quantifying resilience and constructing stability landscapes in systems with discontinuous dynamics (Figure 6.2). It is envisaged that within the next few months these ongoing IRAs will be finalized, and that additional IRAs will be carried out.

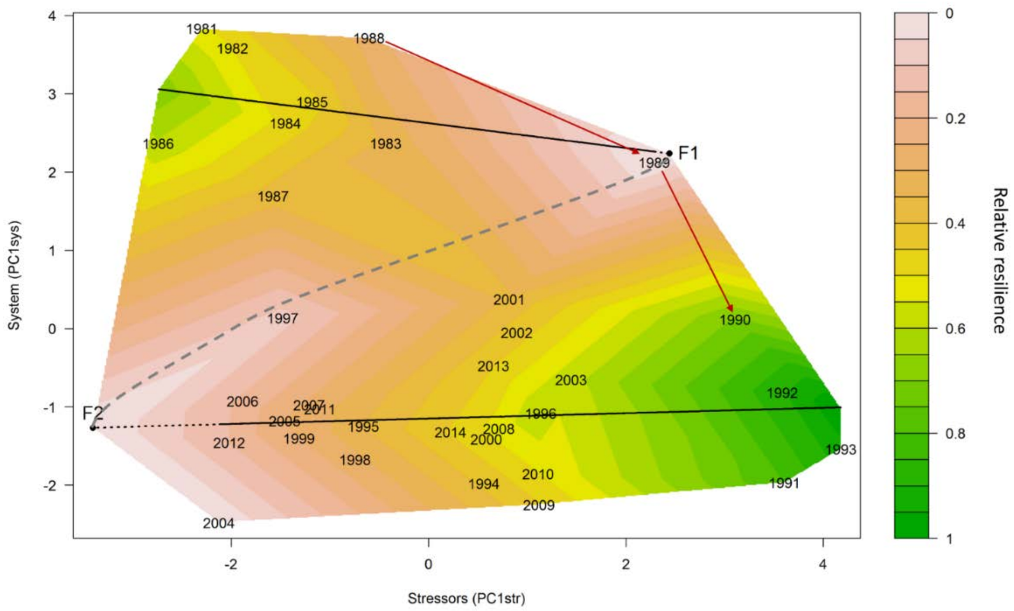

Figure 6.2. The folded stability landscape of the Gotland basin in the Baltic Sea in 1981–2014. The x-axis is the first PC of a PCA carried out on 13 stressor (abiotic) variables (PC1str) and the y-axis is the first PC of a PCA carried out on 10 system (biotic) variables (PC1sys). Continuous black lines indicate the linear attractors, dotted black line indicates the possible extension of the lower branch, dashed grey line indicates the approximate position of the basins' border and F1, F2 indicate the tipping points. Colors represent the relative resilience contour interpolated from the relative resilience of each year. Circles and arrows indicate the 1989 regime shift.

5.1.3 Satellite-based assessment of marine foodweb productivity in European Seas (Ocean Productivity index for Fish) (By Jean-Noël Druon, presented by Paris Vasilakopoulos)

The generic Ocean Productivity Index for Fish (OPFish) is a satellite-based indicator of zooplankton productivity, which generally agrees with fisheries data (DCF by ICES subrectangles and quarters). The OPFish product is particularly relevant to WGCOMEDA as it is comparable across the European Seas, it may be integrated in time and space to match fisheries data from the original resolution (few km, daily) and disentangles the environmentally- from the fishing-driven effect of the high trophic level productivity (see first description in Druon, 2017). An index trend of +4.2% decade^{-1} from 2003 to 2017 is observed at a basin scale under the current effect of climate change, with regional peaks above +20% in relatively poorly productive areas. The OPFish index may be used as input data for full ecosystem models (Figure 6.3).

Since about 90% of the energy flow is lost at each trophic step, it is essential to ecosystem modelling to identify the ocean processes that are mostly responsible of the transfer of the remaining 10% of the flow, at least from phytoplankton to zooplankton. A common type of ocean features of interest for all trophic levels was identified: chlorophyll *a* fronts. Productive fronts, such as at the edge of eddies or gyres on which OPFish is based, are indeed active long enough (from weeks to months) to allow the continuous production of zooplankton. These mesoscale features were furthermore shown to attract fish and top predators (Druon *et al.* 2017, 2016, 2015; Panigada *et al.*, 2017). It is foreseen that the OPFish index be better described to this WG in 2019 as advances in the forcing of full ecosystem models will be performed in the Celtic Sea and in the Mediterranean Sea.

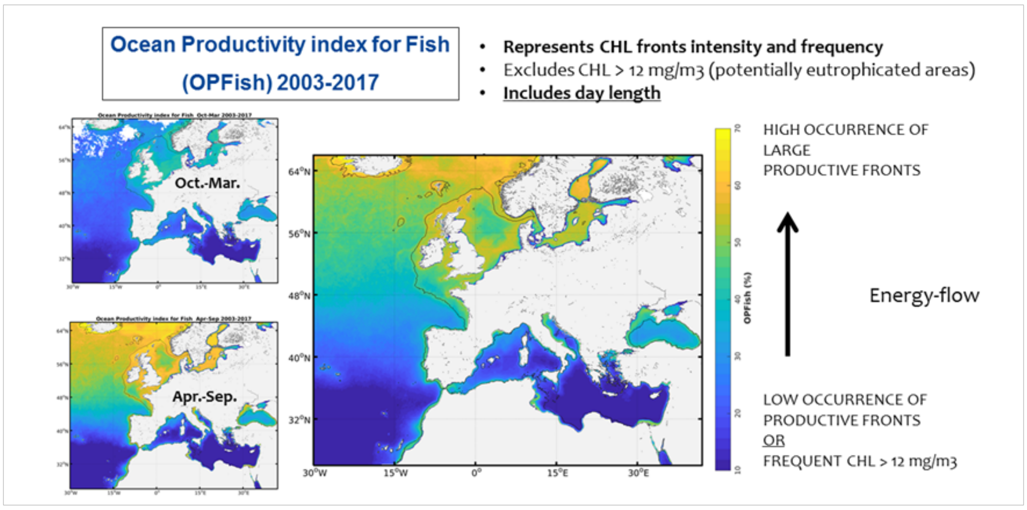

Figure 6.3. Seasonal (left) and mean (right) regional pattern of the Ocean Productivity Index for Fish, along with the main characteristics and interpretation.

5.2 TOPIC 2: Interplay between stability-diversity-resilience: embracing temporal and spatial scales. ToR a (Lead: M. Hidalgo)

After completing the research on the drivers and structural properties of stability at a global scale (Hidalgo *et al.*, in prep), WGCOMEDA work on ecological stability is moving towards two directions: a) the influence size structure in regulating ecological stability (see below Topic 2, by R. Frelat) and b) linking temporal to the spatial patterns of stability. To assess the spatial patterns of stability, we calculated de-correlation scale metrics following the approach by Shackell *et al.* (2012). This approach evaluates changes in the de-correlation distance over time among exploited communities to determine whether temporal changes were related to measures of community life history, evenness or other environmental drivers. We preliminarily applied this approach to three areas: Spanish mainland coast and Alboran Sea in the Mediterranean, and the Galicia-Cantabric Sea in the Atlantic. While in the Mediterranean areas we did not observe any temporal pattern, we did in the Atlantic where a clear change in the de-correlation scale was observed in 1997–1998 (Figure 6.4). This implies that in the first period the population was more unstable, most likely due to the high impact of fishing at that time, which is consistent with species-specific estimates (Modica *et al.*, 2014). However, from 1998 onwards, the community shifted to a more stable system with larger de-correlation scale, likely due to the decrease of the fishing impact that led to increase the abundance of larger fish and also, the increase of spatial occurrence several species and diversity towards the last decades (Punzón *et al.*, 2016; Hidalgo *et al.*, 2017). For next year, the approach will be replicated in other areas as well as on a matrix based on life-history traits information.

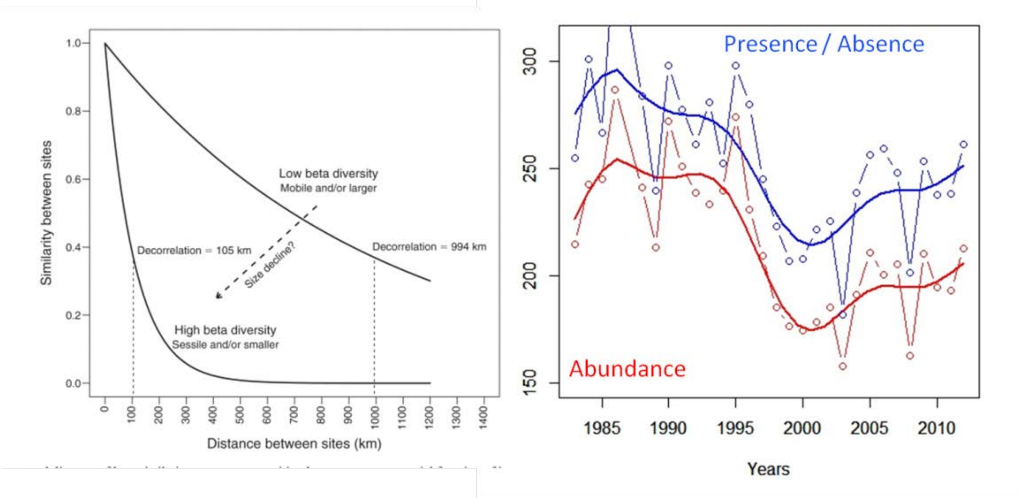

Figure 6.4. Schematic representation of the de-correlation scale calculated based on the relationship between similarity matrix and the geographic distance between sampling stations (left, from Shackell *et al.* (2014). Temporal pattern of the de-correlation scale for the Galician-Cantabric Sea using abundance and presence/absence data (right).

5.3 TOPIC 3: Worldwide assessment of stability in pelagic ecosystems. - ToR a (Lead: J. Otero and I. Catalán)

Two metrics of stability (synchrony and portfolio effect) were assessed in 43 stocks of pelagic species worldwide in order to investigate geographical segregation of stability as well as potential drivers. Preliminary analyses on the fluctuations of abundance-at-age for all these stocks show that less synchronous stocks have a higher mean-variance portfolio and a large number of age classes (Figure 6.5). This was predicted the theory but never shown empirically in the context of pelagic fish populations. The preliminary analyses also show that species with a higher von Bertalanffy growth parameter (K) display more synchronous fluctuations. Furthermore, elevated exploitation rates and higher temperatures imply more synchrony within stock fluctuations (Figure 6.5). Taken together, internal and external factors seem to have an influence on the stability on community of small pelagics in worldwide waters (Figure 6.5). For next WG meeting, analyses will be complemented according to the comments and suggestions received in the meeting.

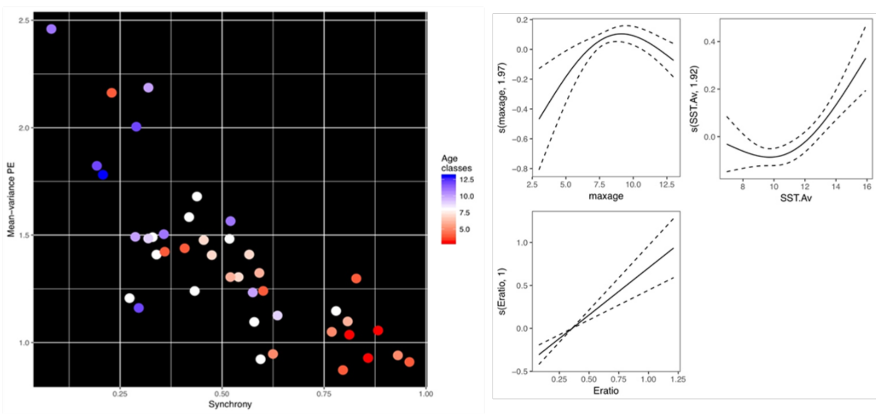

Figure 6.5. Relationship between mean-variance portfolio and synchrony for 43 stocks of small pelagic species in worldwide waters. Dots are colored according to maximum assessed age for each stock. (left). Partial effects obtained from fitting a GAM model to the synchrony data as a function of maximum age, average sea surface temperature and exploitation rate (right).

5.4 TOPIC 4: Interplay between taxonomic and structural (size-based) stability across contrasting European marine system - ToR a (Lead: R. Frelat)

The relationship, if any, between diversity and stability has puzzled ecologists for decades. Most studies use taxonomic classifications to understand why and under what conditions the community is more stable than the sum of its parts. However, fish populations, for example, are known for their strong ontogenetic-trophic niche shift, suggesting a size-based classification of individuals that complement information on its functional role. A size-based approach to study the Diversity-Stability Relationship was presented in order to understand the influence of the size distribution on the stability of the community. The study is based on a data collection of more than 25 000 fisheries hauls covering most of the European marine ecosystems (Baltic Sea, North Sea, European Atlantic Shelf, and the Mediterranean Sea). After compiling long-term (>20 years) time-series of fish abundances in 23 distinct areas, stability indicators were calculated with both the taxonomic and size classification. The size-based approach presented provides new insights into the dynamics of communities, complementary to the view offered by taxonomic diversity. Particularly, the study shows that size structure contribute to the stability of the community dynamics, especially when few species dominate (Figure 6.6). Knowing the importance of size distribution in the stability of fish communities, relevant advices for marine ecosystem based management could be provided. More areas will be included for the final analysis of this study.

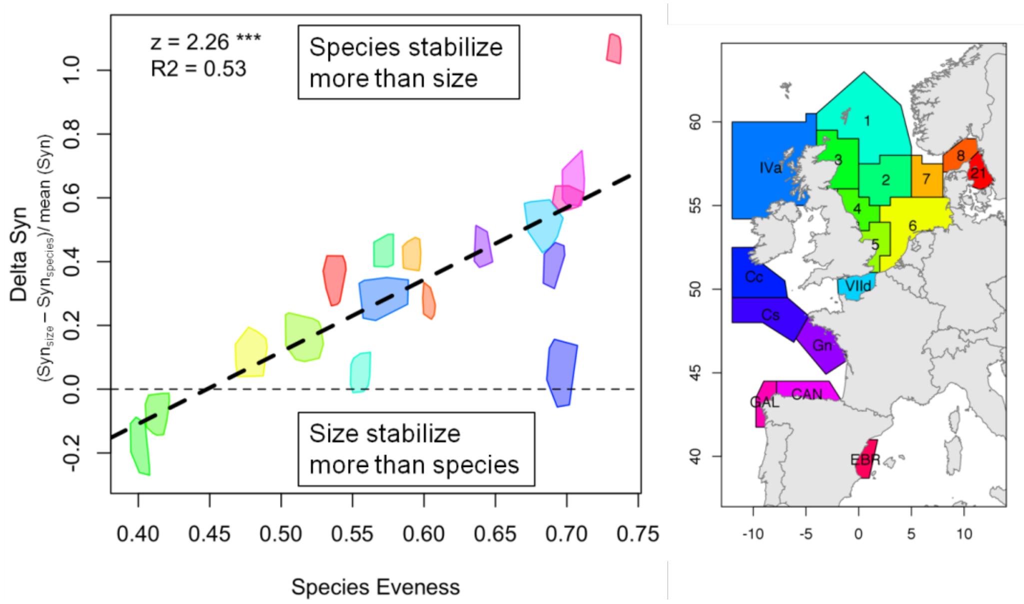

Figure 6.6. Relationship between species evenness and the contribution of synchrony based on taxonomic information and on size (left). Different colors code with different study areas (right).

5.4.1 How to include intraspecific inter-individual variability of biodiversity measures: application to MEDITS data in the Gulf of Lion (By Eliot Sivel)

Diversity measures are numerous. Although there are several types of measures, the most studied over the last decade is the functional diversity. It has been shown that a there is a link between the functional diversity and the functioning of ecosystems. However functional diversity indices based on functional traits do not take in account the intraspecific variability as it summarize the traits a mean values. The aim of our study is to develop a framework that estimates functional diversity accounting for intraspecific variability using the Hill numbers (Chiu and Chao, 2014). To provide an application of our developed framework, we proposed to use one single trait, which is size as it is widely used in many ecological questions and the MEDITS survey's data since individuals systematically underwent length measures.

The framework given by Chiu and Chao (2014) defines a dissimilarity matrix to standardize species relative abundances. In this case, authors defined this matrix using Rao's entropy. This matrix is obtained using a distance matrix between each length class (1 cm length classes), which is multiplied with the species relative abundances. Thanks to the dissimilarity matrix, it is possible to calculate the α-, β- and γ-diversities and to plot the Hill diversity profiles.

The results presented showed that the intraspecific variability is non-negligible when diversity is measured. It appears that the intraspecific variability increases the α- and γ-diversity and that it contributes from 20% to almost 60% to measure. Nevertheless, the intraspecific variability only affects the α- and γ-diversity since no contribution to β-diversity has been shown in our study.

5.5 TOPIC 5: Traits-based approaches (TB) on benthic species- ToR b (Lead: H-Hinz)

Traits based studies often investigate the effect of anthropogenic stressors on individual traits weighted by abundance or biomass aiming to identify individual traits that respond to a stressor. By dissembling species and pooling traits information in this way there is the danger of introducing considerable noise into the traits-based analysis. The responds of a species to a stressor does often not depend on one single traits but on a combination of traits some of which may be related in opposing direction to the stressor. Taking fishing disturbance as an example, generally species living on the surface of the seabed are highly likely to be affected, however if these species at the same time have a highly resistant shell they may survive trawling impacts. If "living position – surface" is now used as a single explanatory trait, the species will contribute little towards an effect. If we have several species with a similar traits combination, it could be concluded that trawling had little or no effect on organisms that inhabit the seabed surface. While this may be true for the particular area analysed due its species composition other areas may show different responses. Thus, analysing the responses of single traits has the potential to introduce bias and lead to spurious conclusions about the impact of stressor on any singular trait. Furthermore, due to these confounding traits, the conclusions drawn from these types of studies cannot easily be generalized to other areas with different species compositions and thus the predictive power of results is limited and at large specific to only the respective study area.

To overcome some of the shortcomings of the traits-based approach it has been suggested to use more directed subsets of traits that are a-priori logically linked to a stressor or an ecological function instead of using all or a single trait. Within the present paper, we introduce a traits-based approach to investigate the effects of trawling on ecosystem function through a more directed set of trait combinations. Based on the observations that the vulnerability of a species to trawling is not random but related to the habitus and the behaviour of a species we developed a physical "Resistance index" for benthic species using traits related to this aspect. Furthermore, we developed a "Resilience (Recovery) Potential index" considering traits related to the reproductive strategies and growth. These two indices were subsequently combined into an overarching vulnerability ranking index that we named Resistance and Resilience index or RRI (Resilience – within this paper is used as a synonym for the potential to recover after trawling impact) (Figure 6.7). This index can subsequently serve to group species into different vulnerably categories and the responses of these to trawling can be investigated. Furthermore, the RRI opens up the possibility of community stress tests or simulation scenarios that link vulnerability directly to ecosystem function indices. Within this paper, we explore both the idea of stress scenario modelling and the use of RRI as a descriptive index using data from two fishing grounds, one located in the Irish Sea (Altantic) and the other in the Catalan Sea (Mediterranean) as case studies.

The concept and approach of this new method has been presented at the World Conference on Marine Biodiversity in May 2018, Montreal (Canada). The work is now in a prepublication stage and will be submitted for publication this autumn. The indices developed will subsequently be adopted for other regional seas for an interregional comparison. Other work such on functional reference points have also been envisaged to be studied soon.

Within the subject of trawling impacts, we are currently also applying for a Marie Curie Fellowship associated to the WGCOMEDA to investigate if prey changes due to trawling effect fish species in the Mediterranean.

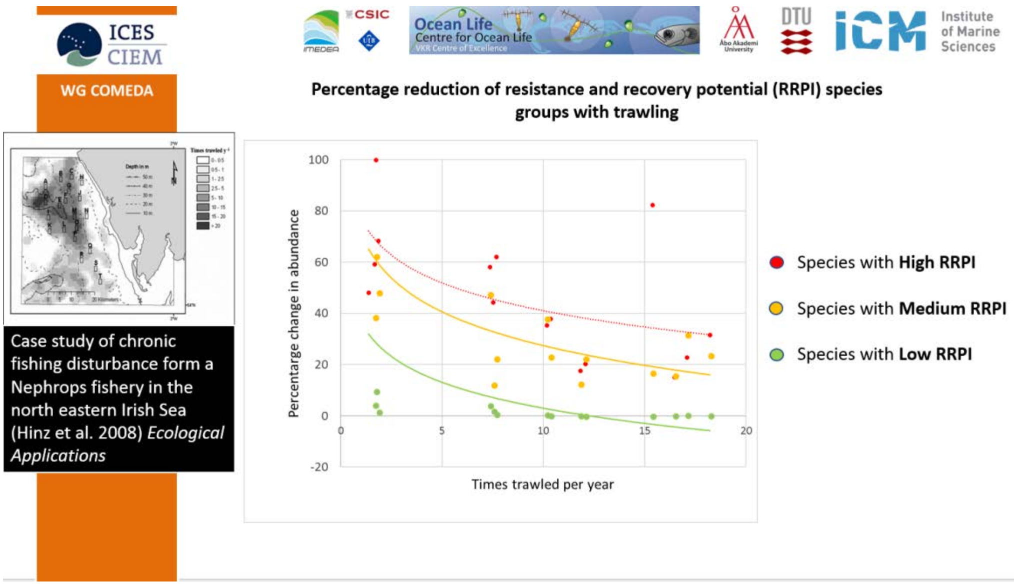

Figure 6.7. Percentage reduction in RRPI species groups along a trawling gradient. Species with a high RRPI trait score have highly resistant trait characteristics to trawling while lower RRPI have traits vulnerable to this activity. The percentage reductions shown validate the assumed vulnerability to trawling of RRPI groups.

5.5.1 Definition of Benthic Habitats Sensitives to bottom trawling: process-driven vs. indicators approaches (By Sandrine Vaz)

Many definitions of ecosystem sensitivity have already been developed (Holling, 1973; Tilllin, 2010). In all of these definitions, sensitivity is understood as (1) the vulnerability of an individual, a species, a population, a community or a habitat to an adverse impact of external factors, natural or anthropogenic (as opposite of stability); (2) the time necessary to return to the previous state (recoverability or resilience).

Process-driven seafloor habitat sensitivity (PDS) has been defined from the method developed by Kostylev and Hannah, which takes into account physical disturbances and availability of energy for growth and reproduction as structuring factors for benthic communities by relating species' biological traits to environmental properties (Kostylev, 2007). In this approach, physical environment maps are converted into a map of benthic habitat types and it is assumed that undisturbed low productivity habitats would more likely contain slowly growing and slowly reproducing sessile species, while highly disturbed habitats would be more suitable for mobile species with shorter lifespan and high reproduction rates. Because PDS outputs are based on idealised "natural" environment, *in situ* observations of benthic communities remain necessary to validate or contrast the established models in the presence of existing large-scale human impacts. One of such indicators is a Trawl Disturbance Indicator (TDI), used on the European shelves, where intensive fishing has been undergoing for several decades over extensive areas (Eigaard *et al*., 2017). The indicator (de Juan *et al.*, 2012; Foveau *et al*., 2017), based on benthic species biological traits (mobility, fragility, position on substrata, average body size and feeding mode), was proposed for evaluating sensitivity of mega- and epifaunal communities to fishing activities affecting the seafloor (e.g. dredging and particularly bottom trawling). The selected biological traits were chosen because they determine individual vulnerability to trawling and they can be easily related to the fragility, recoverability and vulnerability concepts described earlier. Both the process-driven and biological traits approaches seem appropriate to investigate benthic habitat sensitivity. Moreover the differences between PDS, interpreted as a potential sensitivity descriptor, and TDI, which accounts for the abundance of sensitive species effectively observed, may be proposed as a helpful indicator to illustrate the distance that separates us from the good environmental status objectives.

A first application of the proposed framework was applied the English Channel and aimed to evaluate sensitivity of benthic habitats to trawling impacts by using the two approaches 1) a process-driven approach to predict the distribution of sensitive benthic communities (PDS), and 2) an index derived from *in situ* observations focusing on relevant biological traits (TDI). Additionally, the effect of recent bottom fishing impacts (evaluated as observed seabed abrasion by bottom trawling) in explaining potential differences between approaches 1 and 2 was investigated. This approach revealed a good correlation between PDS and TDI, which could be further improved by the addition of bottom fishing effort descriptor. This result hinted that fishing has a detectable impact on benthic sensitivity that could be detected at mesoscale (Foveau *et al.*, 2017). The same approach was more recently applied to the western Mediterranean basin with a focus on the Gulf of Lions (GSA7) where *in situ* data were also available (Figure 6.8). These showed that the relationship between PDS and TDI had broken down to the point where it was no longer significant and fishing effort only could explain currently observed sensitivity of benthic habitats. Perspective of improvement of this work was presented and potential extension to other Mediterranean or Atlantic areas where discussed.

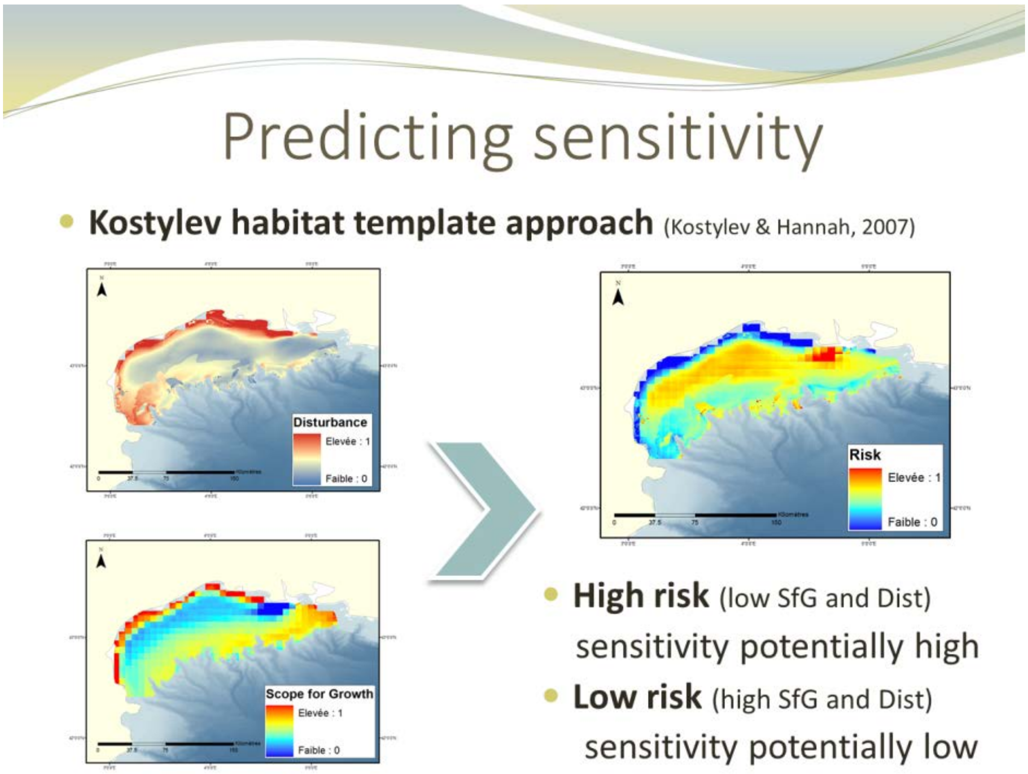

Figure 6.8. Process-driven seafloor habitat sensitivity (PDS) produced for the Gulf of Lions.

5.6 TOPIC 6: Traits-based approaches in contrasting Mediterranean ecosystems (Lead by Vangelis Tzanatos)

Within the framework of the Ecosystem Approach to Fisheries, the project 'Biological traits analysis of fisheries resources: From populations to the Ecosystem Approach to Fisheries Management' (BATFISH) aims to evaluate fish community assembly and dynamics and how it may affect ecosystem functioning using biological traits (Figure 6.9). In this context and based on an already assembled dataset of 21 traits for 205 species, WGCOMEDA work will attempt to answer two questions: (a) What is the quantitative distribution of traits in different habitat types and across environmental variables and (b) Whether a temporal change in traits composition has occurred and (if yes) to determine if it followed a continuous or a discontinuous pattern. Combining traits-based approaches and Integrated Resilience Assessment (see above Section 6.1.2) will allow the identification of traits distribution patterns in space and the determination of taxonomic and/or functional changes in time providing insights to comprehend fish community resilience (structural, functional) using empirical data. Adopting this approach in analyses of data from multiple areas can allow comparative works between European Atlantic and Mediterranean marine ecosystems as framed within WGCOMEDA.

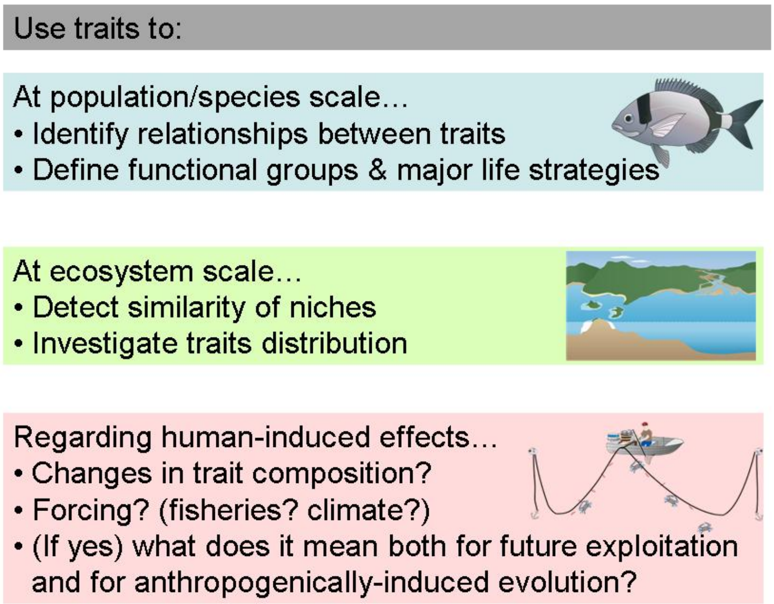

Figure 6.9. General framework for the already performed and future traits-based analyses within the BATFISH project. Within the Ecosystem Approach to Fisheries traits will be used across three scales (population, ecosystem, landscape/human-induced) to provide a functional aspect of the ecology of fisheries resources.

5.6.1 Using biological traits of Mediterranean fisheries resources to investigate life-history strategies and potential interspecific competition (Lead by Martha Koutsidi, presented by V. Tzanatos)

Analysing of population traits can provide insights of how life-history strategies will improve the management under an integrated approach. Within the framework of the project 'Biological traits analysis of fisheries resources: From populations to the Ecosystem Approach to Fisheries Management' (BATFISH) mentioned above the present study aims at detecting relationships between fisheries resources traits and life-history patterns. Regarding traits relationships, correlation and non-linear/linear regressions were used to detect continuous traits relationships. Patterns between continuous and categorical traits were examined with ANOVA/t-test (or their non-parametric equivalents), while trait category co-occurrence was employed to detect relationships among categorical traits. For all relationships mentioned above, the effects of anthropogenic stressors (e.g. fisheries, climate change) on the trait composition of fish communities were explored. Life histories were examined with Archetypal Analysis and Multiple Correspondence Analysis (MCA), indicating in both cases three main life histories (Figure 6.10). Decision Tree analysis described species niches by the creation of terminal nodes (niches), occupied or vacant, combining hierarchically, using four niche descriptors (distribution, ecology, biology, and behaviour) gave an insight into the shaping of ecological niches in the fish community and provided empty (unoccupied niches). Specifically, it used four niche descriptors (distribution, ecology, biology, and behaviour), combining them in a hierarchical fashion, and determined species niches with species appearing in terminal nodes of descriptor combinations. Apart from showing species in their (occupied) niche, it also indicated vacant niches. Together with the results of MCA, they helped identify species occupying similar niches, giving important information for management like the absence of potential competitors for lessepsian species or competitors for species occurring in important habitats.

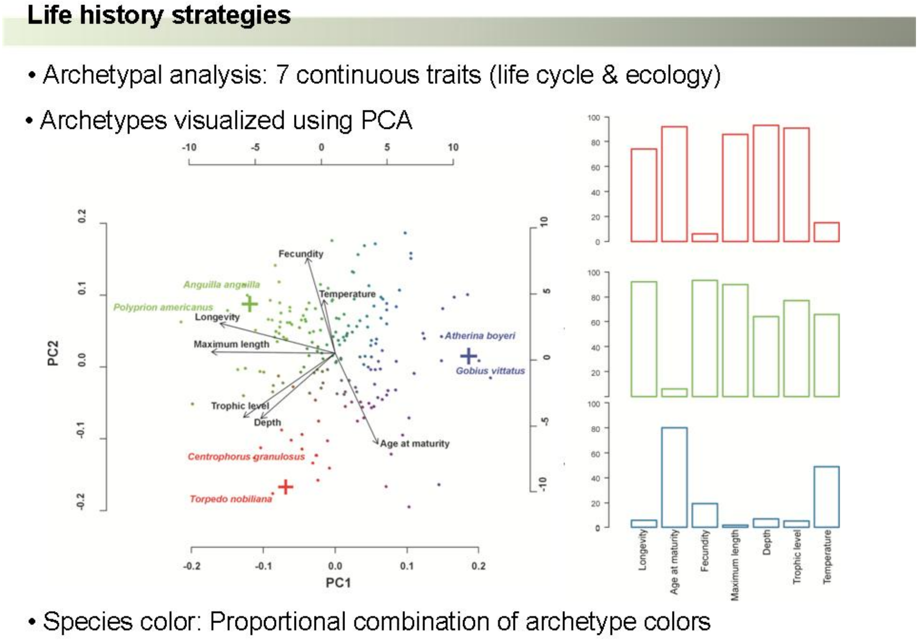

Figure 6.10. Biplot of the PCA performed on the seven traits. The archetypes are visualized as colored crosses. Each species is represented by a point, in which color is a proportional combination of the colors of the archetypes (left). Barplots visualizing the percentage of the traits used, to the archetypes (right).

5.7 Additional research topics presented

5.7.1 Small-scale fisheries economic portfolio effect on income variability (By Luis Outeiro).

Variability of catches and prices are one of the most important sources of the uncertainty when fishers decide to obtain permits for fisheries. The starting point of this work is based on the concept and theory behind the fishers' decision-making when choosing a set of fishing gears permit to exploit in a given season. We focus our study on the small-scale fisheries of Galician Ria de Arousa. Ria de Arousa small-scale fishing fleet is made of a total 1800 vessels with 3150 fishers, which represents 42% of the Galicia fleet (n=3900), and 22% of the Spain fleet (n=7200). In this area, fishing vessels can registered up to a maximum of five fishing gears from more than 30 fishing gears in a given year. Our preliminary results show that the mean number of species is negatively correlated with income variability from landings (Figure 6.11). So, as high is the mean number of species targeted by vessels of our fleet, as low is the income variability. We can conclude that the number of species targeted in a given permit and the combination of fishing gears has a clear positive effect on reducing fishing income uncertainty.

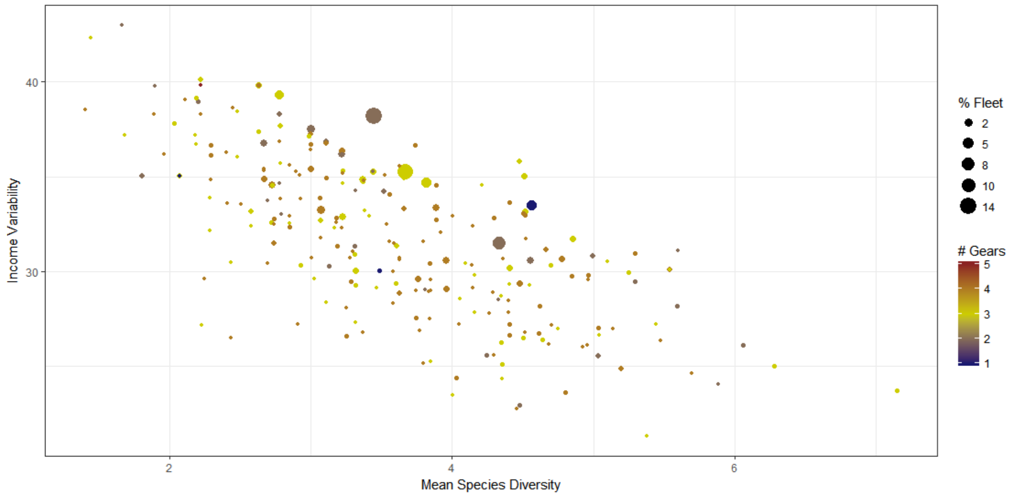

Figure 6.11. Relationship between mean numbers of species is negatively correlated with income variability from landings.

5.8 Cooperation with other working groups

Back-to-back meeting between WGCOMEDA, WGIAB and WGEAWESS was not developed this year 2018. However, this combined meeting is being considered to be replicated in 2019. Several research topics such as Topics 1 lead by C. Möllmann, as well as the parallel work leaded by P. Vasilakopoulos (Section 6.1.2), s a research activity specifically designed to embrace effort and activities between WGCOMEDA, WGIAB and WGEAWESS.

5.9 Cooperation with Advisory structures

The WG has secured the official support from the General Fisheries Commission for the Mediterranean (GFCM). Furthermore, GFCM sees WGCOMEDA as a possible vehicle to ask specific scientific questions with respect to the overarching theme of the WG. Following the memorandum of understanding that exists between the two organizations, the WG can develop as an important vehicle in perusing this collaboration between both ICES and GFCM by both organizations. As a part of the activities planned for 2018, one of the members of the group, Sandrine Vaz, attended the annual MEDITS coordination meeting and, on behalf of the WGCOMEDA chairs transmitted to a broad Mediterranean community the current and the ongoing activities being developed under the second 3-year cycle of WGCOMEDA. For 2019, the communication channel will be maintained and one of the chair will attend the annual MEDITS coordination meeting.

6 Revisions to the work plan and justification

Not applicable.

7 Next meeting

The next meeting will take place in May 2019 in Mallorca (Spain) or Ispra (Italy).

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Annex 1: List of participants

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Annex 2: Agenda

5th meeting of the ICES Working Group on "Comparative Analyses between European Atlantic and Mediterranean marine ecosystems to move towards an Ecosystem-based Approach to Fisheries" (WGCOMEDA)

Sète, France, 29–31 May 2019

Tuesday 29/05/18

13.30–14.00. Arrival of participants

14.00–14.30. Practical information, presentation of participants, objectives and structure (i.e. initial topics), and setup of the WGCOMEDA meeting.

Discussion of the general agenda and potential modification.

- **Topic 1**: Transferring and adapting methods and tools on Integrated Ecosystem Approaches (IEA): setting common IEA exercises in regional systems of the Atlantic Ocean and the Mediterranean Sea (Christian Möllmann).
- **Topic 2**: Interplay between stability-diversity-resilience: embracing temporal and spatial scales (Manuel Hidalgo).
- **Topic 3**: Worldwide assessment of stability in pelagic ecosystems (Jaime Otero and Ignasi Catalan).
- **Topic 4**: Interplay between taxonomic and structural (size-based) stability across contrasting systems (Romain Frelat).
- **Topic 5**: Traits-based approaches (TB) on benthic species: novel methodologies to develop comparative analyses and implementation of size information (Hilmar Hinz).
- **Topic 6:** Traits-based approaches on affected ecosystems: a first approach on contrasting Mediterranean ecosystems (Vangelis Tzanatos and Paris Vasilakopoulos).

TOPIC 1

14.30–15.30. **Setting common IEA exercises in regional systems of the Atlantic Ocean and the Mediterranean Sea** (Christian Möllmann):

Data compiled, potential techniques to be used, preliminary analyses.

15.30–16.00. Coffee break

16:00–16.45. **Recent Integrated Resilience Assessments (IRAs) in the NE Atlantic and the Mediterranean** (Paris Vasilakopoulos).

17:45–17.30. **Satellite-based assessment of marine foodweb productivity in European Seas** (Paris Vasilakopoulos on behalf Jean-Noël Druon).

17.30–18.00 **Discussion on next steps, coordination for developing analyses, agreement on tasks for the topic.**

20.00. Common dinner if wanted.

Wednesday 30/05/18

<u>TOPIC 2</u>

09.00–10.00. **Interplay between stability-diversity-resilience: embracing temporal and spatial scales** (Manuel Hidalgo).

10.00–10.30. **Synthesis discussion on the topic 2: summary of agreements, work to be developed, additional ideas and definition of tasks.**

10.30–11.00. Coffee break

<u>TOPIC 3</u>

11.00–12.00. **Worldwide assessment of stability in pelagic ecosystems** (Jaime Otero and Ignasi Catalan).

12.00–12.30. **Synthesis discussion on the topic 3: summary of agreements, work to be developed, additional ideas and definition of tasks.**

12.30–14.00. Lunch break

<u>TOPIC 4</u>

14.00–15.00. **Interplay between taxonomic and structural (size-based) stability across contrasting European marine systems** (Romain Frelat).

15.00–15.30. **How to include intraspecific inter-individual variability in biodiversity measures: application to MEDITS data in the Gulf of Lion** (Elliot Sivel).

15.30–16.00. **Synthesis discussion on the topic 4: summary of agreements, work to be developed, additional ideas and definition of tasks.**

16.00–16.30. Coffee break

<u>TOPIC 5</u>

16.30–16.45. **Traits-based approaches (TB) on benthic species: novel methodologies to develop comparative analyses and implementation of size information** (Manuel Hidalgo on behalf Hilmar Hinz).

16.45–17.15. **Definition of Benthic Habitats Sensitives to bottom trawling: process-driven vs. indicators approaches** (Sandrine Vaz).

17.15–18.00. **Synthesis discussion on the topic 5: summary of agreements, work to be developed, additional ideas and definition of tasks.**

Thursday 31/05/18

<u>TOPIC 6</u>

09.00–10.00. **Traits-based approaches in contrasting Mediterranean ecosystems Vangelis** (Vangelis Tzanatos).

10.00–10.30. **Using biological traits of Mediterranean fisheries resources to investigate life-history strategies and potential interspecific competition** (Martha Koutsidi)

10.30–11.00. **Synthesis discussion on the topic 6: summary of agreements, work to be developed, additional ideas and definition of tasks.**

ADDITIONAL/POTENTIAL TOPICS

11.00–11.45. **Economical portfolio in artisanal fisheries** (Luis Outeiro).

11.45–13.00. **Final WGCOMEDA Session.**

- Wrap-up of each topic.
- Discussion on venue for the next meeting.
- Planning of the report.
- Report writing.

13.00. **Meeting closure**

13.00. Final Lunch