ICES WGEAWESS REPORT 2018

INTEGRATED ECOSYSTEM ASSESSMENTS STEERING GROUP

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Interim Report of the Working Group on Ecosystem Assessment of Western European Shelf Seas (WGEAWESS)

5-9 March 2018

Nantes, France

ICES
International Council for the Exploration of the Sea

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Executive summary

The ICES Working Group on Ecosystem Assessment of Western European Shelf Seas (WGEAWESS) meeting was held in Nantes, France, on 5-9 March 2018. The meeting was attended by 20 participants (6 via correspondence) from 5 countries and chaired by Steven Beggs, Northern Ireland(UK) and Eider Andonegi (Basque Country, Spain). This was the second year of the new three-year Terms of Reference (ToR) for WGEAWESS and the main activities for the group at this meeting were to discuss progress and further development of work towards all the ToRs a) Continue metadata compilation for all ecosystem components available for IEA development, b) Continue evaluation of data and trends for a regional Integrated Ecosystem Assessment, c) Review and update the regional Ecosystem overviews, d) Develop and apply ecosystem models to fill identified gaps in empirical data for use in IEAs, and e) Development of Interreg Atlantic Area proposal (a second call was just opened on March 2018 and the group agreed on working on a new proposal, aiming at making progress towards the implementation of an IEA in the Western European Shelf Seas, trying to harmonize the process throughout the whole region).

The group continued reviewing available data and information (ToR a) for the regions covered by the group, providing updates where new information was collected or gathered.

Progress made in different regions regarding ToR b) were discussed. Regarding ITAs, different methods were presented and discussed, based on the recently published research highlighting that the current statistical methods used for these analysis (mainly PCAs) might be not the most appropriate techniques (see Planque *et al.*, 2018). A comparison exercise was conducted aiming to analyse potential differences between different techniques. Additionally, updated ITAs for different subregions were presented. Ecosystem overviews for the two ecoregions covered by the group (Celtic Seas and Bay of Biscay and Iberian waters) were reviewed and sections on climate change effects on these two ecoregions were provided. New ecosystem and foodweb models were shown by several group members, looking mainly at the responses of the ecosystem to the fishing activity. An integrated assessment of the region was also carried out using the MSFD approach, and a practical example was shown about the use of these complex models for management, focusing on Marine Spatial Planning. Finally, a new AtlantEA2018 proposal was developed by the group, to be submitted to the second call of the Interreg Atlantic Area Programme, with the initial discussions about the new structure and contents of the project proposal taking place during the meeting.

1 Administrative details

Working Group name

Working Group on Ecosystem Assessment of Western European Shelf Seas (WGEAWESS)

Year of Appointment within the current cycle

2016

Reporting year within the current cycle (1, 2 or 3)

2

Chairs

Eider Andonegi, Spain

Steven Beggs, UK

Meeting venue

Nantes, France

Meeting dates

06–09 March 2018

2 Terms of Reference a) – e)

ToR	Description	Background	Science Plan topics addressed	Duration	Expected Deliverables
a	Continue metadata compilation for all ecosystem components available for IEA development	Process initiated and completed for specific subregions in previous ToR. Other subregions in draft.	4.3	3 years, progress updated annually	Database linked to ICES for Regional Sea Programmes
-b	Continue evaluation of data and trends for a regional Integrated Ecosystem Assessment. Identify ecosystem trends relevant to stock assessment and management	Linked to WKECOVER, WKRISCO, WKDECOVER, and the commitment to provide advice in the context of EBAFM	4.2, 4.1	3 years	Report IEAs and provide advice to fisheries groups as appropriate
c	Review and update the regional Ecosystem overviews	Linked to ACOM-SCICOM advice	4.2	3 years	Ecosystem overviews
d	Develop and apply ecosystem models to fill identified gaps in empirical data for use in IEAs	This would be linked to activities conducted under previous ToRs	4.1	3 years	Regional modelling prodcuts
e	Development of Interreg Atlantic Area proposal	Funding is being sought to increase the resources and participation of the group		1 year	Successful fund capture

3 Summary of Work plan

Year 1	The main task will be the development of a proposal for Interreg funding. the group will also be involved with providing advice to WKIrish. We will continue to identify and catalogue datasets available that would be potentially valuable in an IEA and EBAFM. Ongoing analysis of important trends in ecosystem indicators. Improve communication with relevant advice groups (fisheries stock assessment).
Year 2	Continue with Year 1 activities while liaising with relevant ICES WG membership. Development of ecosystem models to fill identified gaps in empirical data for use in IEAs. Scope of IEA and model development will be dependent on successful Interreg funding.
Year 3	Continue with Year 2 activities while liaising with relevant ICES WG membership. Development of ecosystem models to fill identified gaps in empirical data for use in IEAs. Scope of IEA and model development will be dependent on successful Interreg funding.

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

Poster and Oral presentations (2017):

- Altuna, M. and Andonegi, E. (2017) Moving towards the Ecosystem Approach to Fisheries in the Bay of Biscay. Poster to the Advances in Marine Ecosystem Modelling Research (AMEMR) Conference. Plymouth, July 2017.
- Andonegi, E. (2017). Integrated Assessments as the main goal for achieving an Ecosystem Approach to Management in the Western European Shelf Seas. Oral at ICES WGHANSA meeting. Bilbao (Spain). Jun 24-29, 2017
- Andonegi, E. and Prellezo, R. (2017). Is the Ecosystem Based Fisheries Management a reality in the Bay of Biscay? Analyzing the effects of the implementation of the Landing Obligation at an ecosystem level. Poster to the MareFrame Scientific Conference "Advances in Ecosystem-based Fisheries Management". Brussels, December 2017.
- Canseco JA, Torres MA, Ramos, F. 2017. Spatial patterns and inter-annual variability of mid-size pelagic fish species off the Gulf of Cadiz. Poster to the ICES Annual Science Meeting (Fort Lauderdale, Florida, USA, 18-21 September 2017).
- Carvalho-Souza GF, González-Ortegón E, Baldó F, Drake P, Ramos F, Sobrino I, Vilas C, Llope M. Natural and land-based human factors affect the abundance of anchovy in the Gulf of Cadiz (SW Spain). Poster at the 4th International Symposium 'The Effects of Climate Change on the World's Oceans', Washington DC (USA), Jun 4-8, 2018. Accepted.
- Carvalho-Souza GF, González-Ortegón E, Baldó F, Drake P, Ramos F, Sobrino I, Vilas C, Llope M. Natural and land-based factors in the Guadalquivir estuary affect the abundance of anchovy in the Gulf of Cadiz (SW Spain). Poster (and poster presentation) at ICES ASC 2017, Fort Lauderdale (Florida, USA), Sep 18-21, 2017.
- Carvalho-Souza GF, Llope M, Baldó F, Vilas C, Drake P, Ramos F, González-Ortegón E. Natural and anthropogenic factors in the Guadalquivir estuary affect the abundance of anchovy in the Gulf of Cadiz (SW Spain). Oral presentation at International Symposium: Drivers of dynamics of small pelagic fish resources, Victoria (Canada), Mar 06-11, 2017.
- Gamaza MA, Torres MA, Acosta JJ, Erzini K, Sobrino I. The future of the Gulf of Cadiz multispecies trawl fishery under the 'zero' discards policy. Oral presentation to the International conference on advances in marine technologies applied to discard mitigation and management. 2-4 May 2018, Vigo (Spain). Accepted
- González-Ortegón E, Llope M, Baldó F, Sobrino I, Fernández-Delgado C, Drake P, Vilas C. Modelling the effect of environmental and anthropogenic factors on the abundance of early life-history stages of the European sardine in the Guadalquivir estuary. Poster at International Symposium: Drivers of dynamics of small pelagic fish resources, Victoria (Canada), Mar 06-11, 2017.
- Kadin M, Casini M, Torres MA, Blenckner T, Gårdmark A, Otto S. Coupled foodweb indicator models and scenario simulations identify robust indicators guiding management actions. 2017. Oral presentation to the ICES Annual Science Meeting (Fort Lauderdale, Florida, USA, 18-21 September 2017).
- Llope, M. *et al.*, Estuarine and marine environmental effects on the Gulf of Cadiz anchovy dynamics. Oral presentation at ICES WGHANSA meeting. Bilbao (Spain). Jun 24-29, 2017.

- López-López L, Preciado I, Arroyo NL, Castro J, Carrera P, Cerviño S, Iglesias M, Morato T, Muñoz I, Nogueira E, Prado E, Punzón A, Saavedra C, Sánchez F, Serrano A, Somavilla R, Torres MA. 2017. Ecological trends in the Cantabrian Sea ecosystem: A modeling approach including trophic controls. Poster to the MareFrame Scientific Conference "Advances in Ecosystem-based Fisheries Management" (Brussels, Belgium, 14th December 2017)
- Pedreschi, D. & Reid, D.G. ODEMM in the Celtic Seas: A Qualitative IEA with Decision Support Tools. MareFrame: Co-creating Ecosystem-based Fisheries Management Solutions, Brussels, Belgium, December 2017.
- Pedreschi, D., Andonegi, E.,de Fatima Borges, M., Llope, M., Beggs, S. & Reid, D.G. WGEAWESS: Integrated Ecosystems Assessment of the Western European Shelf Seas. ? Oral presentation to the ICES Annual Science Conference, Fort Lauderdale, Florida, USA, September 2017.
- Torres MA, Erzini K, Borges T, Campos A, Castro M, Santos J, Costa E, Fernandes AC, Marçalo A, Oliveira N, Vingada J, Fonseca P. 2017. An ecosystem modeling approach for evaluating the EU Landing Obligation impact on the Portuguese bottom trawl crustacean fishery. Poster (and poster presentation) to the ICES Annual Science Meeting (Fort Lauderdale, Florida, USA, 18-21 September 2017).
- Torres MA, Erzini K, Borges T, Campos A, Castro M, Santos J, Costa ME, Marçalo A, Oliveira N, Vingada J, Fonseca P. Ecological impacts of adopting the discard ban policy in the deep-water crustacean trawl fishery off Southern Portugal. Oral presentation to the International conference on advances in marine technologies applied to discard mitigation and management. 2-4 May 2018, Vigo (Spain). Accepted

Publications by group members:

- Bentley, J.W., Serpetti, N., Heymans, J.J., (2017). Investigating the potential impacts of ocean warming on the Norwegian and Barents Seas ecosystem using a time-dynamic food-web model. Ecological Modelling, 360, 94–107. https://doi.org/10.1016/j.ecolmodel.2017.07.002
- Bundy A, Chuenpagdee R, Boldt JL, Borges MF, Camara ML, Coll M, Diallo I, Fox C, Fulton EA, Gazihan A, Jarre A, Jouffre D, Kleisner KM, Knight B, Link J, Matiku PP, Masski H, Moutopoulos DK, Piroddi C, Raid T, Sobrino I, Tam J, Thiao D, Torres MA, Tsagarakis K, Van der Meeren GI, Shin Y-J. (2017). Strong fisheries management and governance positively impact ecosystem status. Fish and Fisheries 18 (3), 412-439.
- Llope, M. (2017). The ecosystem approach in the Gulf of Cadiz. A perspective from the southernmost European Atlantic regional sea. ICES J Mar Sci, 74: 382-390
- Pedreschi, D., Bouch, P., Moriarty, M., Nixon, E., Knights, A.M., & Reid, D.G. Integrated Ecosystem Analysis in the Celtic Seas; Providing the Context for Ecosystem-based Fisheries Management. Submitted to Fisheries Research, special issue on 'Advancing Ecosystem-based Fisheries Management' Feb 2018.
- Rincón, M. M., Catalán, I. A., Mäntyniemi, S., Macías, D. & Ruiz, J. (2018). Embedding anchovy survival in the environment with a dual time resolution: A Bayesian state-space size-structured population dynamics model. Fish. Bull.116:34–49
- Ruiz, J., Rincón, M. M., Castilla, D., Ramos, F., & del Hoyo, J. J. G. (2017). Biological and economic vulnerabilities of fixed TACs in small pelagics: An analysis of the European anchovy (*Engraulis encrasicolus*) in the Gulf of Cadiz. Marine Policy, 78, 171–180.
- Scott, E, Serpetti N., Steenbeek, J., Heymans, J.J. A Stepwise Fitting Procedure for automated fitting of Ecopath with Ecosim models. SoftwareX (2016), 5, 25-30. doi:10.1016/j.softx.2016.02.002

- Serpetti, N., Baudron, A.R., Burrows, M.T., Payne, B.L., Helaouët, P., Fernandes, P.G., Heymans, J.J., 2017. Impact of ocean warming on sustainable fisheries management informs the Ecosystem Approach to Fisheries. Scientific Reports-, 7(1), 13438, doi:10.1038/s41598-017-13220-7.
- Torres MA, Casini M, Huss M, Otto S, Kadin M, Gårdmark A. (2017). Food-web indicators accounting for species interactions respond to multiple pressures. Ecological Indicators 77: 67-79.
- Torres MA, Vila Y, Silva L, Ramos F, Palomares MLD, Sobrino I. (2017). Length-weight relationships of 22 crustacean and cephalopod species from the Gulf of Cadiz (SW Spain). Aquatic Living Resources.30: 12. DOI: 10.1051/alr/2017010
- Otto SA, Kadin M, Casini M, Torres MA, Bleckner T. (2018). A quantitative framework for selecting and validating foodweb indicators. Ecological Indicators 84: 619-631

Project proposals:

- Atlantic Area Interreg AtlantEA (not funded) and AtlantEA-II (second trial) to be submitted for the second call (opened from 1 March to 1 June 2018)
- TransEBM - 2017- Transdisciplinary, Coastal and Marine Ecosystem-based Management (EBM) of the Gulf of Cadiz-Gualdaquivir estuary (GoC-Ge). Submitted under the Horizon 2020's Marie Skłodowska-Curie actions call H2020-MSCA-IF-2017. Deadline: 14/09/2017. Score 2018 = 91.2% (not funded, threshold 2018 = 92.5%). Score 2017 = 89.4% - Seal of Excellence 2017. Will probably be re-submitted in 2018.

5 Progress report on ToRs and workplan

Aiming at looking for synergies between WGEAWESS and other ICES WGs, two joint sessions were organized during 2018, the first being focused on the support that WGEAWESS could provide to assessment groups (WGHANSA[1] in this case) and the second, to joint efforts with other (ecosystem) modelling WGs (WGIPEM[2]). In this last case, a joint session with WGIPEM, WGINOSE[3] and WGS2D[4] was organized and attended by several members of the group, that included a presentation of the work done by WGEAWESS during the recent period, leading to interesting discussions with the other WGs.

The progress for the group during this second year of the current period is detailed below, organized by ToR and subregion.

[1] Working Group on Southern Horse Mackerel, Anchovy and Sardine (WGHANSA)

[2] Working Group on Integrative, Physical-biological, and Ecosystem Modelling (WGIPEM)

[3] Working Group on Integrated Assessments of the North Sea (WGINOSE)

[4] Working Group on Seasonal-to-Decadal Prediction of Marine Ecosystems (WGS2D)

5.1 *ToR a)* Continue metadata compilation for all ecosystem components available for IEA development

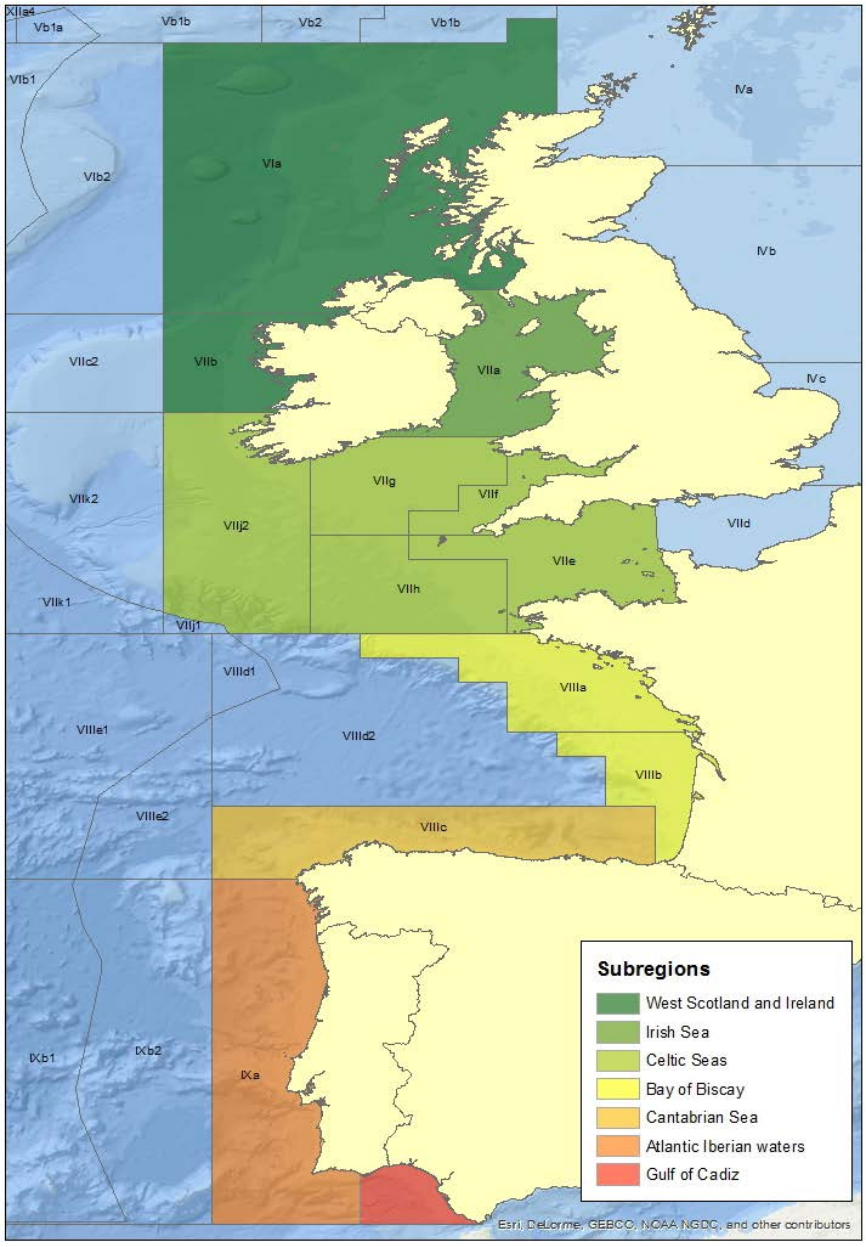

Figure 5.1. Overview of WGEAWESS subregions

The group continues to make good progress in the compilation of metadata for IEA development in many subregions. Given the focus and membership of the group, the metadata collected thus far is primarily related to fisheries. Of particular note in the current recording period was the updating of metadata from the Bay of Biscay and Atlantic Iberian waters. Progress continues in the Gulf of Cadiz where data for the Guadalquivir estuary (Ge) system and the Gulf of Cadiz (GoC) proper have been collated. This work demonstrates the importance for finer scale investigations where important areas are identified such as the Guadalquivir estuary, an important nursey ground for several marine species. No updates for the Irish Sea were provided during the current reporting period. Remaining subregions including the Celtic Seas and West Scotland and Ireland and Cantabrian Sea are data rich, with many data products identified that may be of use in IEA development. Further sources of data for the west of

Scotland and Ireland region were identified with aid from correspondence from regional experts.

As mentioned the focus of the group is primarily related to fisheries, therefore a gap in societal and economic metadata is evident. For a more complete IEA increased interaction with these areas of expertise is needed.

Modelled products were identified as useful in filling gaps in current physical and biological metadata that would provide harmonized products across the subregions. Discussions with the Working Group on Operational Oceanographic Products for Fisheries and the Environment (WGOOFE) were recommended to explore and assess the quality of the current outputs available and the feasibility of acquiring outputs on a regional and subregional basis.

With the volume of metadata and data products increasing in the group, it was suggested that a more structured approach, potentially involving the ICES Data Centre could substantially improve the workflow, including enhanced transparency and repeatability of data used in ITA and future IEA development. This would include the structure, reporting and hosting of metadata, the extraction of time-series and data and the evaluation of data for further use in ITA and IEA.

An overview of the current metadata per region is given below:

West of Scotland and Ireland

Metadata lists will be updated and completed based on the information from regional experts.

Irish Sea

Metadata list was not updated from the previous report. Further scoping of data to represent economic, societal, and pressure trends of the system would be useful.

Celtic Seas

Metadata have been identified including sources of central data such as SAHFOS for zooplankton and Copernicus for oceanographic/physiochemical data. Survey data can be used for raw data if required, some mammal and seabird data available but restricted in time. Data for fish biomass estimates can best be retrieved from stock annexes/WG reports to get a longer timeline than from the surveys, however issues remain with stock areas and the area of interest for the ITA assessment – how we resolve this remains an issue. The OSPAR DATRAS data product may also provide a central data stream that all countries can use that has been consistently treated.

Bay of Biscay

Data compilation and associated metadata have been updated and completed were ever possible for the north Shelf of the Bay of Biscay (Armorican and Aquitain shelves, corresponding to ICEA areas 8ab). An effort was made to improve the structure of the metadata table in order i) to automate the extraction step of variables from their sources, ii) to better discriminate between available time-series and reliable time-series, iii) to specify if the data should be used or not for ITA. Large climatic indices cover a long time-series, while satellite-derived data are more limited (from 1986 onwards for SST, from 1998 onwards for chlorophyll-*a*, and suspended matters). Environmental variables also include the main river flows. It is worth noting that a unique time-series can be used to inform several indicators (e.g. spring chlorophyll-*a*; total annual chloro-

phyll-*a*; date of the chlorophyll-*a* maximum…). So far, identified time-series of zooplankton are very short (less than 10 years) as no CPR data exist on the Armorican and Aquitain shelves. Options were discussed such as using outputs of biogeochemical models to inform on the long-term dynamics of this ecosystem components. Local time-series have also to be explored to assess if they are representative of the entire area dynamics. Similar conclusions arose for the benthic invertebrates compartment, with no sufficiently long time-series existing at the shelf scale.

Abundance indices of bentho-pelagic species are available in this area since 1987, from a bottom-trawl survey, and for pelagic species from 2000 from an acoustic survey. Time-series of top predators (birds and mammals) start around 2000 as well. International landings, informing both on species abundance and fishing effort, are available since 1950, while fishing effort for different French fleets is available since 1999. Other human activities are much more recent, therefore the associated time-series are very short.

Portuguese waters

For the Portuguese area, there is a need to compile existing time-series corresponding to *in situ* nutrients, phytoplankton and zooplankton, benthos and also *in situ* oceanographic data. There are also marine mammal and seabird data available but restricted in time. Data for fish stock biomass and recruitment estimates might be retrieved from stock assessment models outputs, nevertheless for ITA analysis is considered to be more appropriate to use observed data corresponding to the study area rather than outputs from models. Special care is needed regarding the area mismatch of the stock managed and the area surveyed corresponding to the ecosystem that we want to analyse. Stock assessment estimates may be useful to help in inferences to raise survey biomass indices as well as fleet CPUEs and total catch for Ecopath modelling input data.

Gulf of Cadiz

The Gulf of Cadiz is composed of two major components: the Guadaqluivir estuary (Ge) and the Gulf of Cadiz (GoC) proper. Due to the relevance of the estuary as a nursery ground for several marine species, time-series were extracted for these two components independently. For the Guadalquivir estuary (1997–2015) data came from the following sources: (i) Guadalquivir LTER and (ii) Confederación Hidrográfica del Guadalquivir. Estuarine variables included temperature, salinity, turbidity, precipitation, discharges, eight functional groups (including fish and mysids). For the marine side of the Gulf of Cadiz (1993–2015) data were extracted mainly from: (i) bottom-trawl (ARSA) and pelagic (STOCA) surveys, (ii) satellite images, (iii) Agencia Estatal de Meteorología and (iv) IEO fisheries statistics. Biotic variables comprised +30 functional groups including planktonic (phyto- and zooplankton), pelagic and demersal (fish and invertebrates). Environmental variables included wind indices, surface/bottom temperature and salinity while human pressures considered landings, fishing effort or marine mammal strandings.

Concerning the degree of development of ToR a) in the GoC region, the Guadalquivir estuary dataset has been generated while the GoC one was refined (in terms of functional groups), enlarged (including new variables) and updated (until 2015) compared to previous years (2015 report). The two databases will need to be continuously updated but we can consider the ToR as accomplished.

5.2 *ToR b)* Continue evaluation of data and trends for a regional Integrated Ecosystem Assessment. Identify ecosystem trends relevant to stock assessment and management

With the increasing number of datasets identified, the group discussed the need to critically evaluate the data for continued use in IEA and EBFM developments. As an initial evaluation framework, the work of the Working Group on Ecosystem Effects of Fishing Activities (WGECO) and the Working Group on Biodiversity Science (WGBIODIV) indictor criteria was highlighted as demonstrated by the related Working Group on the Northwest Atlantic Regional Sea (WGNARS). A recent publication by WGNARS highlighting the pros and cons of this approach for IEA development (De Piper *et al.*, 2017). A table of the criteria is available in the 2013 Report of the Working Group on Ecosystem Effects of Fishing Activities (WGECO).

To identify data needs for a fisheries-based IEA the group have traditionally refer to Dickmann *et al.* (2009) which outlines key components of the ecosystem that should be included:

- hydroclimatic conditions;
- nutrients;
- phytoplankton;
- zooplankton populations;
- macrozoobenthos;
- top predators, such as seals, seabirds;
- major fish stocks;
- Fisheries for each subecosystem.

This "wishlist" is fisheries oriented representing the expertise of the group. For further IEA development other indicators of the ecosystem including human activities, economic and societal indictors, habitat, and biodiversity indicators would need to be considered.

WGEAWESS reiterates that a cooperative science document or similar for developing ITAs was needed as recommended during the Workshop on Integrated Ecosystem Assessment Methods (WKIDEA). Recent criticism of the use of PCAs for IEA development has highlighted the need for clear guidelines in the use of these multivariate methods. Concerns over PCA use were discussed but it was felt that with appropriate data screening and cautious interpretation of the PCA outputs the approach was useful in detecting long-term trends and patterns in the time-series available.

The group had a thorough discussion and presentations on a number of alternative methods for screening and presenting time-series, a summary of which follows:

Methods beyond ITA

The methods presented here were developed within the past EU project Fisboat to identify changes in series of indicators. These methods were published in 2009 in a special issue of the journal Aquatic Living Resources, volume 22(2), available here: https://www.alr-journal.org/articles/alr/abs/2009/02/contents/contents.html. Scripts in R for applying the methods are available as supplementary material attached to the publications. Three methods were presented and discussed: Decision CUSUM, Min/max autocorrelation factors (MAF) and Multiple factors analysis (MFA). Decision CUSUM (Mesnil and Petitgas, 2009) is useful for identifying statistically significant deviations from a reference mean, rapidly. The method requires defining a reference period, where mean, variance and distribution of the index series are characterized. The CUSUM is then tuned with two parameters and serves to monitor whether the mean

deviates with time from the reference mean. One parameter influences the time to detection (mean run length) of the change in the mean after it has happened. The other parameter relates to the deviation in the mean that can be detected with a given time to detection. Applying the method on many indices results in building a "traffic light" table, where changes are monitored with such statistical framework (Petitgas *et al.*, 2009). The method can also be used to monitor changes in spatial patterns, when applied to amplitude series of EOFs (Woillez *et al.*, 2010).

The MAF analysis of time-series (Woillez *et al.*, 2009) was developed to rank series of indices among a large list, based on the continuity in time-series. For instance, the approach allows to select those series showing the most continuity in time. The rationale for such selection is to identify those series, which can be interpretable more easily because they are continuous (i.e. trend, oscillation). In contrast, indices showing erratic variability (i.e. white noise) will be ranked last. Although interesting, they cannot be used to assess any change in the ecosystem. MAF is a double PCA, where the second PCA is performed on the increments (at a given lag D) of the PCs of the first PCA, allowing to rank those series with smaller variogram value at lag D. The method was applied to more than 100 indices derived from the integrated pelagic survey PelGas in the Bay of Biscay (Doray *et al.*, 2017). Trends were identified for particular series, including the reduction of length-at-age 1 in anchovy and sardine since 2000. The discussion pointed out different approaches to select indices for assessing ecosystems. Even if trends in particular indices show changes, the fact that other indices are erratic is also informative. From the discussion, it was suggested to compare the results of MAF with that of ITA on an example case study.

Multiple table analysis (MFA) may serve to characterize the consistency in time of the correlation structure among many indices (Petitgas and Poulard, 2009). The method requires to organize the data in a three-dimensional structure, where for each time-step the elementary data matrix is composed of the same indices (columns) sampled at the same (spatial) sample stations. The method amounts to performing a PCA on the combined elementary matrices, which have been previously standardized by their first Eigen value and appended by column. The factorial space constructed allows to separate the variability of space from that in time. Each (spatial) sample station is represented geometrically by an average point in time and also by as many points as there are time-steps. The method was applied to a list of indices in the major ecosystem compartments of the Bay of Biscay derived from the integrated pelagic survey PelGas (Petitgas *et al.*, 2017). A hierarchical classification of the time average station positions in the factorial space resulted in identifying and mapping ecosystem subregions. The variability of time was quantified by the inertia in the factorial space around the time average station positions and was mapped, showing areas with greater variability than others. The deviation in time from the average spatial structure could be monitored, for instance by using CUSUM. The discussion raised the issue of identifying ecosystem limits. It was suggested that a similar analysis could be performed at the scale of the WGEAWESS region to identify subsystems and characterize their temporal variability.

ODEMM – Options for Delivering Ecosystem-Based Marine Management

WGEAWESS continues to support the development and use of ODEMM as an operational tool for EBMM. ODEMM assessments for the Celtic Seas and Irish Sea were presented to the group highlighting the adjustments made to them for the group's specific purposes. Both assessments present a 'current status' precautionary assessment, rather than a risk forecasting assessment. The Irish Sea assessment splits *Fisheries* into its con-

stituent parts – Beam trawl, Bottom trawl, Pelagic fishing, Dredging, and Potting. *By-catch* is treated as a separate pressure to *selective extraction of species* in both the Celtic Seas and Irish Sea assessments, and *Discards* is further separated out in the Irish Sea Assessment. The Celtic Seas assessment has further been linked through to the MSFD descriptors.

Questions arose in relation to the applicability/transferability of the results to other areas, and the aggregation of the scores across linkages (e.g. summing vs. averages) and how these affect rank orders. While many of the linkages may be transferable to wider areas than the study area, it would need to be comprehensively reviewed to ensure agreement with the assessment, and to adjust (at a *minimum*) that overlap and frequency scores of the sectors for different areas. Expert panels from different areas are likely to have different opinions on scores and importance of different impacts – but it may be easier (and perhaps more efficient) to adapt a current assessment than start a new one – stakeholders may be more willing to change scores that seem wrong, than to propose values *de novo*. It is important to note however that it would depend on the requirements of a given area/region – for instance, the focus on fisheries in the Irish Sea arose from the fact that *fisheries* rose to the top of the Celtic Seas analysis, and the group's particular interest in fisheries and EBFM.

It was also noted that climate change is not included in the assessment as an explicit pressure. It is difficult to include, as it is not easily incorporated as a pressure due to difficulty in specific management action to reduce/mitigate it, at least on a national level. Including it as a sector would also not adequately reflect its interactive effects with other pressures, a noted shortcoming of the ODEMM approach, which considers direct effects only. Climate change will certainly have effects on the pressures and ecological characteristics that are assessed, but no current method has been developed for incorporating this into the approach.

Further work has been conducted to develop the ODEMM linkage framework visualization using online tools. The Linkage Framework can help with decision support and visualization of the system and provides the structure within which management options can be explored.

West of Scotland and Ireland

Further ITA development for this subregion is hoped to progress in the current reporting year

Irish Sea

The ITA for the Irish Sea continues to be used to inform the WKIRISH initiative. No update to previous report.

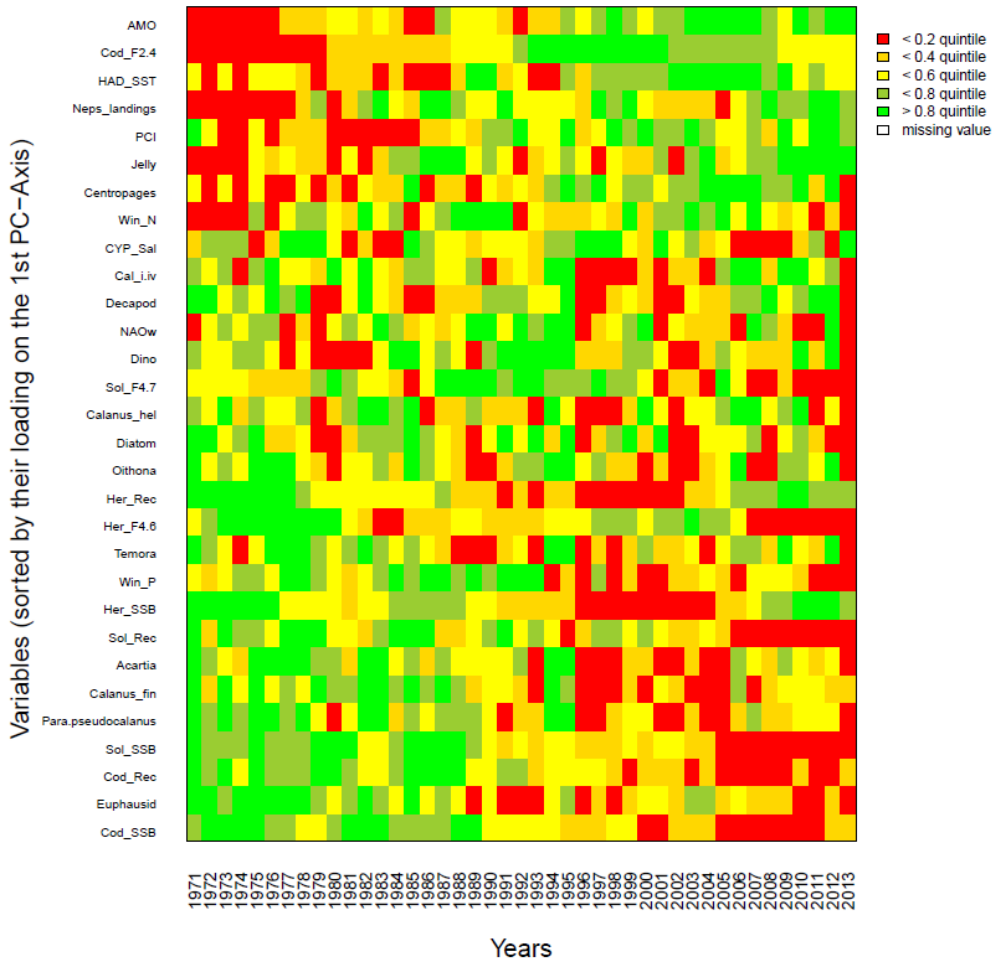

Figure 5.2. Traffic light plot of the temporal development of the Irish Sea ecosystem time-series. Variables are transformed to quantiles, colour coded (red- high values, green- low values) and sorted in numerically descending order according to their loadings of the first principle component

Celtic Seas

Further ITA development for this subregion is hoped to progress in the current reporting year

Bay of Biscay

Preliminary results of two exploratory ITAs were presented to the group. The first encompassing the years 1987–2016, while the second shorter time-series (2000–2016) including data from the integrated ecosystem survey (PELGAS). Physical Data included SST and salinity values, with large climatic drivers represented by the AMO and NAO. The French IBTS EVHOE survey provides a number of biotic variables mostly of fish populations. Finally, ICES landings of key stocks were also included. Date were transformed prior to PCA analysis. Further work will be carried out to explore further datasets and refine the ITA during the current reporting year.

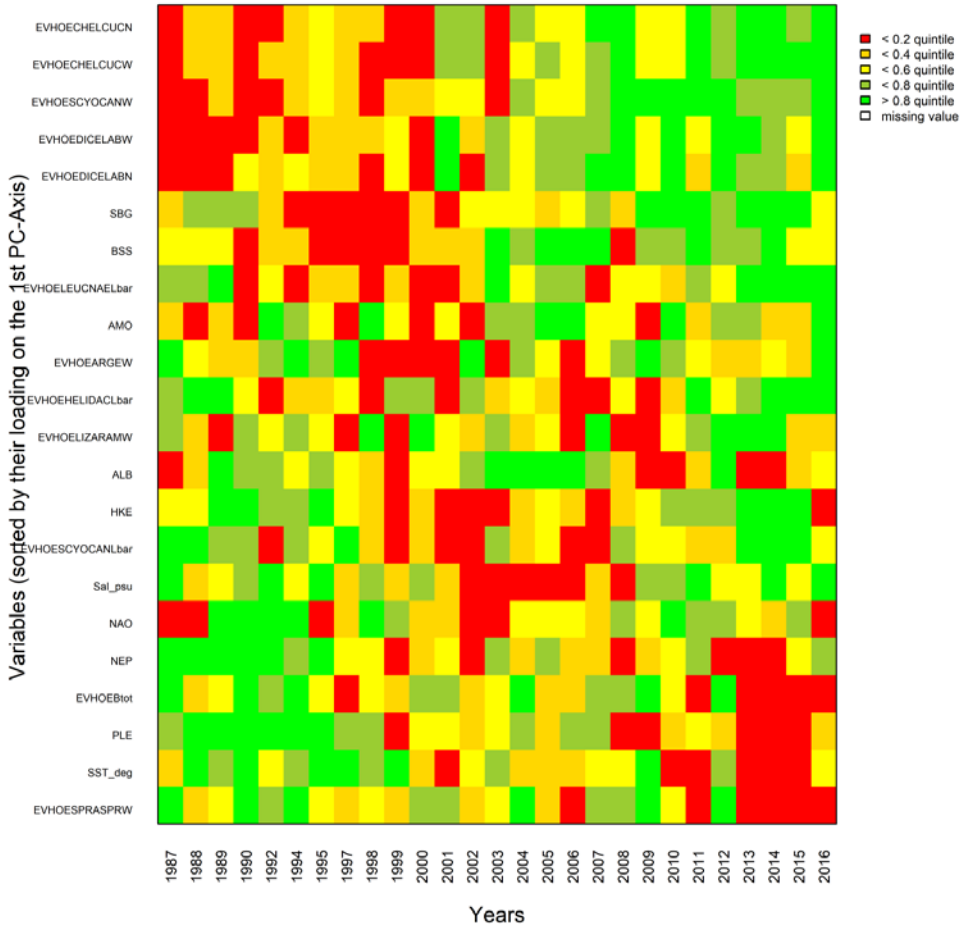

Figure 5.3. Traffic light plot of the temporal development of the Bay of Biscay ecosystem time-series. Variables are transformed to quantiles, colour coded (red- high values, green- low values) and sorted in numerically descending order according to their loadings of the first principle component.

Portuguese waters

For ITA analysis presented this year for the Portuguese ecosystem, the study area is the same covered by the research vessel sampling described in the DATRAS protocol.

Survey data from 40 fish species from 1986 to 2016 were used to estimate biomass indices by species, extracted from IPMA/PNAB and ICES/ DATRAS databases. 13 stock assessment output variables for; sardine, hake, megrim, and anglerfish recruitment, spawning biomass and fishing mortality were obtained from ICES stock assessments reports.

Ten abiotic variables describing environmental and climatic conditions were included in the analysis. Sea surface temperature anomaly (SST) for the North Atlantic was downloaded from Met Office website (https://www.metoffice.gov.ukhadobshadsst3data), the North Atlantic Oscillation index (NAO), winter and annual mean (http://www.cpc.ncep.noaa.gov/data/teledoc/nao.shtml), the Atlantic Multidecadal Oscillation index (AMO) (http://www.esrl.noaa.gov/psd/data/timeseries/AMO) and eastern pattern index (EA) (http://www.cpc.ncep.noaa.gov/data/teledoc/ea.shtml) were downloaded from the NOAA website and the upwelling index was provided by the Instituto Español de Oceanografía (IEO) (http://www.ieo.interactivo.html).

Preliminary results were presented to the group suggesting that the Portuguese ecosystem might be currently in a new state driven by the complex atmospheric and oceanographic conditions that started in 1995–1996 and intensified in 2003–2004. An overview of the temporal changes in all the time-series from the Portuguese ecosystem are represented by a traffic light plot (Figure 5.4).

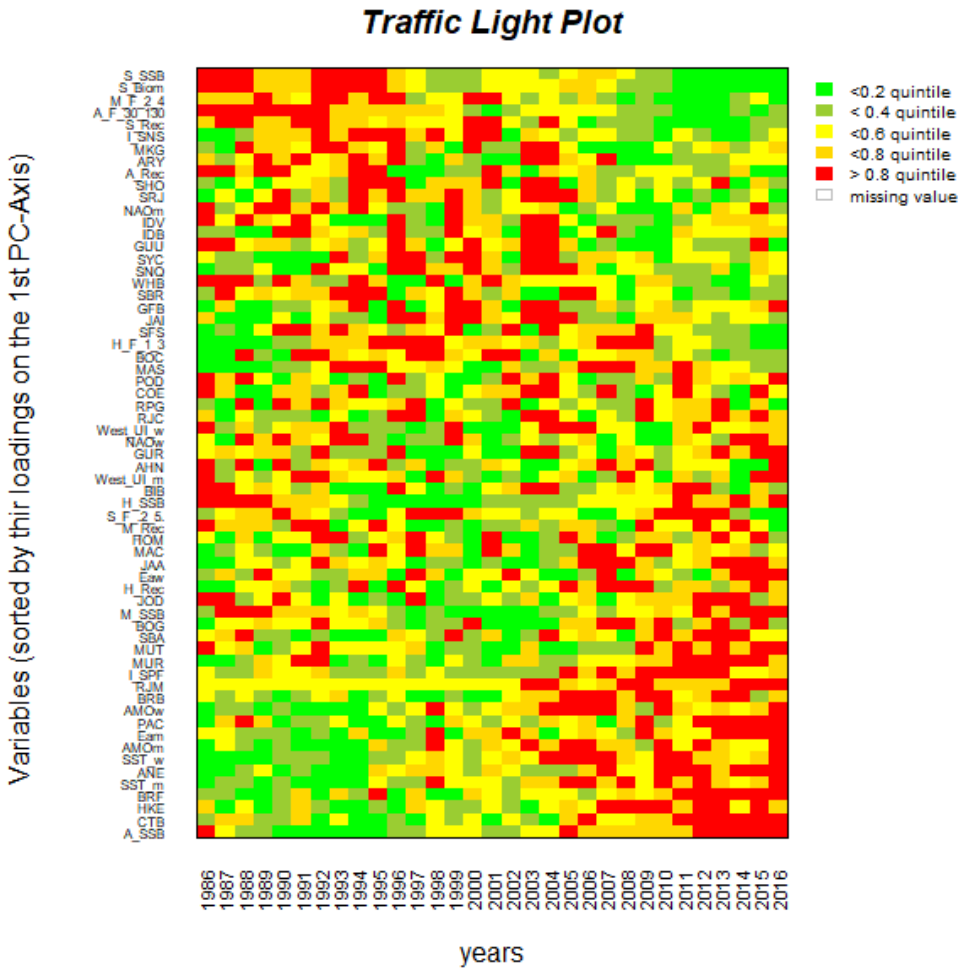

Figure 5.4. Traffic light plot of the temporal development of the Portuguese ecosystem time-series. Variables are transformed to quantiles, colour coded (red- high values, green- low values) and sorted in numerically descending order according to their loadings of the first principle component.

Gulf of Cadiz

A preliminary ITA (traffic light plots and PCA) for the Gulf of Cadiz and Guadalquivir estuary, respectively, was presented by Marcos Llope.

In the Ge a decrease in salinity associated with a decrease in marine assemblages (estuarine fish, marine migrant fish and decapods) can be observed for recent years. At the same time, there is an increase in freshwater discharges and turbidity, which is also detrimental to marine species (e.g. anchovy juveniles). Salinity and freshwater discharges come out as key drivers for principal component 1 (PC1) while turbidity and mysids seem to be important for PC2. These preliminary findings agree with a complementary study using time-series modelling on the same database (Carvalho-Souza *et al.*, in review)

In the GoC the amount of information that has been gathered (>70 categories; including biotic, environmental and pressures) requires a careful selection/inspection before jumping to conclusions. However, preliminary examination reveals some interesting patterns including an increase in top predators (hake, sharks, skates) concomitant with a decrease in bottom trawling since 2005.

In terms of accomplishment of ToR b) we have made good progress in developing and exploring ITAs for further subregions. We hope to show further results next year and look at patterns across the whole region.

Identify ecosystem trends relevant to stock assessment and management

ToR b) also explicitly deals with identifying ecosystem trends relevant to stock assessment and management. In this regard, the group produced a 'species card' for GoC anchovy where we summarized the environmental information that can affect this particular species according to what is known about its ecology and life cycle. This information was presented at ICES WGHANSA 2017 in an effort to increase the impact and knowledge of our IEA group to stock assessment groups by facilitating dialogue between them.

The group discussed the expansion of this process in future and identified stock assessment benchmarks as relevant times in the assessment cycle were ecosystem considerations could be explored in more detail and presented. It was felt that with the experience of the group that through the ICES secretariat the timetable of future benchmarks within the WGEAWESS region could be identified and contact made between the group and benchmark process.

5.3 *ToR c)* Review and update the regional Ecosystem overviews

The climate change template contributing the ICES Ecosystem overviews was reviewed and the group agreed ton populating it with the most up-to date information for the two ecoregions: Celtic Seas and Bay of Biscay and Iberian waters. Experts have expressed concern at some of the text they have been asked to provide due to a lack of knowledge in this area; research is required. The available information will be submitted to the ICES Secretariat to be included in the current Ecosystem overviews.

5.4 *ToR d)* Develop and apply ecosystem models to fill identified gaps in empirical data for use in IEAs

Different modelling approaches have been presented to the group. These have been developed under the framework of different research projects and have slightly different objectives, as detailed below, but they all contribute to inform the IEAs in those areas of WGEAWESS.

Celtic Seas

Impact of ocean warming on sustainable fisheries management informs the Ecosystem Approach to Fisheries.

An integrated ecosystem model including fishing and the impact of rising temperatures, relative to species' thermal ranges, was used to assess the cumulative effect of future climate change and sustainable levels of fishing pressure on selected target species. Historically, important stocks of cod and whiting showed declining trends caused by high fisheries exploitation and strong top–down control by their main predators (grey seals and saithe). In a no-change climate scenario these stocks recovered under sustainable management scenarios due to the cumulative effect of reduced fishing and predation mortalities cascading through the foodweb. However, rising temperature

jeopardized boreal stenothermal species: causing severe declines in grey seals, cod, herring, and haddock, while eurythermal species were not affected. The positive effect of a higher optimum temperature for whiting, in parallel with declines of its predators such as seals and cod, resulted in a strong increase for this stock under rising temperature scenarios, indicating a possible change in the contribution of stocks to the overall catch by the end of the century. These results highlight the importance of including environmental change in the ecosystem approach to achieve sustainable fisheries management.

A Stepwise Fitting Procedure for automated fitting of Ecopath with Ecosim models.

The Stepwise Fitting Procedure automates testing of alternative hypotheses used for fitting Ecopath with Ecosim (EwE) models to observation reference data (Mackinson *et al.*, 2009). The calibration of EwE model predictions to observed data is important to evaluate any model that will be used for ecosystem based management. Thus far, the model fitting procedure in EwE has been carried out manually: a repetitive task involving setting >1000 specific individual searches to find the statistically 'best fit' model. The novel fitting procedure automates the manual procedure therefore producing accurate results and lets the modeller concentrate on investigating the 'best fit' model for ecological accuracy.

"Ecology for all": combining ecosystem modelling and serious gaming to aid transnational management of marine space.

The Maritime Spatial Planning (MSP) Platform Edition is a multiplayer serious game, built to provide stakeholders and maritime planners with insights into the diverse challenges and trade-offs of sustainable planning of human activities in marine and coastal areas. To improve its capabilities in representing the impacts of planning decisions on marine ecology, Ecospace, the spatial-temporal module of the Ecopath with Ecosim (EwE) foodweb modelling approach, was integrated into the MSP game environment. We here present this integration, and discuss how two existing EwE models were adapted to drive the ecology in the MSP games of the North Sea and the Firth of Clyde. Results show that integrating EwE models captures the interplay between fisheries, other marine uses, and ecosystem dynamics, with ecological realism, allowing MSP Platform Edition players to experience realistic management trade-offs between conservation and exploitation of marine resources. We discuss the lessons we learned during the development of these two first cases, and provide guidelines for future EwE integration efforts into MSP games. Finally, we discuss how scientifically informed serious games can translate into important training tools for managers and stakeholders, advancing their understanding on integrated ecosystem management, and ultimately, promoting a better-informed management of marine resources, especially across borders and in transboundary situations.

Irish Sea

In line with the ICES Strategic Plan to progress towards integrated ecosystem assessments and the ongoing process of the Benchmark Workshop on the ecosystem-based management of the main Irish Sea fish stocks (WKIrish), a need to develop multispecies modelling capabilities in the Irish Sea was identified. The combined use of Ecopath with Ecosim (Christensen *et al.*, 2008) and multispecies fish community modelling (Thorpe *et al.*, 2015) was advocated as suitable for this purpose. Much of the data needed to populate these models are readily available in the literature, however, as with most complex ecosystem models, data collected for non-commercial species is not always as extensive as data collected for commercial species. The aim of the new EwE model building is to investigate the drivers surrounding the dynamics of

commercially important species in the Irish Sea, (cod, haddock, plaice, whiting, sole, herring, and *Nephrops*). have been included as individual functional groups.

The model is hoped to inform future management, by helping to understand why cod, and other stocks, have acted as observed. Further questions that may be explored:

- Are stocks slow to recover due to trophic dynamics?
- Are they still being overexploited by anthropogenic means despite efforts?
- Has the increasing temperature of the Irish Sea, or any other environmental driver, influenced the behaviour of the Irish Sea foodweb?
- Modelling the foodweb in the Irish Sea in the context of a depleted commercial fish community

Bay of Biscay

Integrated ecosystem assessment with a spatial mechanistic model (ISIS-Fish)

Pierre Issac presented his PhD project that started in October 2017 about developing a framework and modelling tool for ecosystem assessment in the Bay of Biscay area (8ab) meant to provide stakeholders with relevant information for management purpose. As a first step, a network of the relevant ecosystem compartments (Abiotic and Human Pressure effect on Biotic) will be built based on previous analyses. An interactive web tool (Shiny App, RStudio) will display available knowledge of compartment variables and their associated datasets (Time-series extent, resolution, and sources). Data mining methods (Random Forest, PLS, Dynamic Factor Analysis) will be applied to empirically quantify the strength of the links between compartments. In a second step, a focus will be done on fisheries related ecosystem compartments. The relationships empirically corroborated will be modelled using ISIS-Fish (www.isis-fish.org) which is a spatially explicit mechanistic model that describes fishing activity (fleets, strategies and métiers) in relation to the dynamics of the target species and management. Two ISIS-Fish model are already built in Bay of Biscay area 8a and 8b that describe respectively pelagic fleets (targeting anchovy, sardine, sea bass, and albacore tuna) and demersal fleets (targeting hake, Norway lobster, and sole). These models will be merged to investigate different management issues regarding interaction between fisheries, and between marine human activities, as well as environmental effects on fish and fisheries. In a third step, we will investigate the impacts of scenarios of change in management, climate conditions, and use of the marine space.

Foodweb-fisheries modelling in the Bay of Biscay

A statistical foodweb-fisheries model is under development for the Bay of Biscay (ICES Division 8abd), Northeast Atlantic. The main objectives are to evaluate the structure of the foodweb and its changes over last 15 years (2000–2015) as well explore management scenarios for different fishery fleets. The model is a fully Bayesian multivariate Gompertz-style autoregressive state-space model with unknown biological, process uncertainty, catchability, and observation uncertainty parameters. The model was fit to various time-series (total landings, CPUE by broad gear class and survey indices). The model results suggest that the Bay of Biscay ecosystem exhibits very strong top–down density-dependent control, in particular by demersal piscivores, which have increased over the study period while all other functional groups remained more or less stable. However, the long-term stationary distribution is very uncertain. This uncertainty is probably a result of many model parameters and a relatively short time-series. Future work will involve exploring the sensitivity of results to model assumptions and running strategic management scenarios.

Ecosystem evaluation of the Bay of Biscay: Do landings exceed system productivity?

To assess whether fisheries exploitation in the ICES area met the ecosystem level management objective of maintaining overall productivity, historic landings of small species (<1 kg) by large marine ecosystem were compared with multispecies maximum sustainable yield (MMSY) reference levels (Trenkel, 2018). The MMSY values were estimated by Jennings and Collingridge (2015) using a size-spectrum model and several scenarios for the fishing exploitation pattern but only two scenarios were considered here. The results for the Bay of Biscay showed that landings might have reached the MMSY level in the early 1980s but probably never exceeded it since (Figure 5.5). However, it has to born in mind that the MMSY estimates were based on driving system productivity by chlorophyll concentrations and temperature for the years 2010–2012. Hence, the estimated MMSY values are suitable for recent years but might be less appropriate to the earlier period.

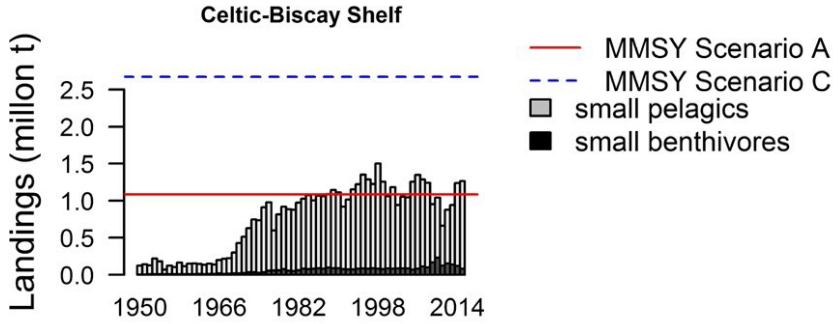

Figure 5.5. Comparison between historic landings of small species (< 1kg) in the Celtic Sea Bay of Biscay large marine ecosystem with multispecies maximum sustainable yield (MMSY) reference levels estimated by Jennings and Collingridge (2015) using a size-spectrum model and two scenarios for the fishing exploitation pattern.

MSFD approach for the ecosystem assessment in the Bay of Biscay.

The Marine Strategy Framework Directive (MSFD), adopted in June 2008, recommends Member States to adopt an ecosystem approach to manage the marine environment. By this directive, France aims to achieve a good environmental status (GES) described by 11 descriptors, of its marine waters by 2020. Descriptor 1 stipulates that biological diversity is maintained. The quality and occurrence of habitats and the distribution and abundance of species are in line with prevailing physiographic, geographic, and climate conditions (European Commission Decision 2017/848/UE). The ecosystem components of fish and cephalopods must be assessed in the four marine subregions ("English Channel – North Sea", "Celtic seas", "Bay of Biscay" and "Western Mediterranean"). The species groups assessed in this report are the demersal fish of sandy or muddy coastal areas, demersal and pelagic fish of the continental shelf, cephalopods of coastal areas and continental shelf, and fish and cephalopods of deep-sea waters. For the assessment of the species groups mentioned above, except for coastal and pelagic fish, the "Celtic seas" and "Bay of Biscay" marine subregions are united in one Assessment Geographical Unit (AGU) and the "Western Mediterranean" marine subregion is divided into two AGU: Gulf of Lion and Eastern Corsica.

The approach used to assess the GES of each species group in each marine subregion is based on the availability of data from scientific surveys conducted by Ifremer and scientific proven methods for identifying thresholds. This quantitative approach is implemented for criterion D1C2 related to the abundance of populations and to the group of demersal fish of the continental shelf for which sensitivity to fishing pressure is high. It is carried out at the population and community level. However, the beginning of

monitoring devices matches with a period of high fishing intensity that does not allow referring to an initial situation without pressure. For the other species groups, criterion D1C2 is indicated by the results of the assessment of Descriptor 3 when stock assessments are available (i.e. D3 report; Foucher and Delaunay, 2018), this is the case of the pelagic fish of the continental shelf, or through a qualitative approach. For the other criteria, a qualitative assessment is proposed. The latter approach describes (albeit non-exhaustively) the state of scientific knowledge of those unassessed species groups. It also suggests future methodological developments, which will likely be used to inform the five criteria of the Descriptor 1 for the next assessments. The assessment of GES of the demersal fish populations of the continental shelf, using the criterion D1C2, indicates that among the 5 AGU, the "English Channel – North Sea", "Celtic Seas and bay of Biscay" and "Gulf of Lion" present populations that don't achieve GES. The number of populations is particularly important in the Gulf of Lion where 28% do not achieve GES. In addition, 30 to 50% of the populations are assessed in GES in all AGU.

The community approach, whose the results are consistent with the previous ones, indicates that the "English Channel – North Sea" AGU shows increasing signals of a return to GES since the 2000s. The populations qualified in GES have doubled since the beginning of the observation series, achieving 40–45% of the populations of sensitive species to the fishing pressure. In the "Celtic seas and bay of Biscay" AGU, the environmental status of the populations is stable over the period analysed but it is difficult to interpret that stability as no threshold value of GES formerly exists. Finally, the western Mediterranean with Corsica and the Gulf of Lion have respectively a stable state and a decrease of the number of populations in GES since the end of the nineties. However, in the Gulf of Lion, signals of a return to a GES are observed for the last MSFD cycle.

The qualitative approach highlights the main developments leading to future operational indicators for the next MSFD cycles. This includes work on the coastal demersal fish communities with the data provided by scientific surveys on nursery areas (D1C5), the ICES work on the size and age based on indicators of exploited fish stocks (D1C3), and research development on the geographical distribution of demersal and pelagic populations of the continental shelf (D1C4).

Portuguese waters

Using foodweb modelling to evaluate ecosystem effects of the crustacean trawl fishing in Portugal

The first Ecopath model to evaluate ecosystem effects of the crustacean trawl fishing in the South and Southwestern continental coasts of Portugal (SSWPT) was presented by Maria A. Torres. This study is in the framework of the MINOUW Project (http://minouw-project.eu/) WP3 on impact assessment of minimizing unwanted catches and discarding.

The study area (ICES 9a) was modelled to represent the year 2000 covering 4000 km^2 at depths ranging from 200 to 700 m. A total of 34 functional groups were included in the model integrated into four trophic levels (TLs) with anglerfish and hake as top predators. The highest flows to detritus corresponded to the groups positioned at the base of the foodweb moving the energy to the upper TLs groups. The main insights underline strong exploitation by the fisheries on the target species. The keystone species/groups identified corresponded to both groups of cephalopods, rose shrimp and mackerels. The SSWPT network possesses a more web-like structure than chain-like with a large number of connections in the foodweb in line to the opportunistic feeding behaviour of deep-sea species. Those indices related to resilience showed that SSWPT

ecosystem had in 2000 relatively low functional redundancy for potential use against natural hazards and environmental disturbances (33%).

The main gaps and limitations arose were discussed with the group associated to biomass underestimation for the demersal and benthic groups, scarce overall information of the benthic and lower TLs groups, local trophic studies and unreported and misreporting landings. Further development of the SSWPT model including temporal dynamic simulations were also introduced in compliance with the EU 'Landing Obligation' (LO). In particular, the main goal will be to evaluate the ecological consequences of using more selective fishing, by means of technical devices to reduce discards, on the SSWPT ecosystem. Similar fishing scenarios will be performed and further compared with the Bay of Biscay model in collaboration with Eider Andonegi to investigate if both ecosystems will respond similarly or differently to the LO implementation by exploring the Network Analysis and ecosystem indicators outputs.

5.5 *Tor e)* Development of Interreg Atlantic Area proposal

The group dedicated a whole session to review and improve the AtlantEA proposal that was submitted to the first call of the Interreg Atlantic Area Programme. The comments received from the proposal reviewers and national contact points were taken as basis of this brainstorming. Work planned in the first AtlantEA proposal was removed in order to better match the requirements of this new call, but ensuring that our initial goal that was addressing the ToRs of WGEAWESS by developing the research needed for that was still covered by the new AtlantEA2018 proposal. Hard work was developed by the group on improving this new AtlantEA2018 proposal during the following months and was finally submitted on 1 June 2018.

6 Revisions to the work plan and justification

There were no revisions to the work plan this year

7 Next meetings

The next meeting will be hosted by the IEO in Cadiz, on 8–12 April, 2019.

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Annex 2: Recommendations

Recommendation	Adressed to
1. Produce a list of potential assessment groups (e.g. WGBIE, WGCSE, WGDEEP, WGEF, WGHANSA, WGWIDE, HAWG) for WGEAWESS to produce species cards and provide ecosystem data (similar to the ones produced for cod and anchovy, see 2017 report) that could be used as part of benchmark processes at ICES.	ICES Secretariat
2. To provide some Guidelines about: • Data extraction and provisioning best practice • ITA/MAF step-by-step userguide	ICES Secretariat
3. To host and advice the metadata database	ICES Secretariat
4. Related to the Ecosystem overviews: • Provide details for how the network diagrams are created • Better harmonize and homogenize all the EOs	ICES Secretariat
5. Request a generation of time-series for temperature (for example) both for the near term and the long term for our area to start exploring about the implications of accounting for them in our future scenarios	ICES WGS2D
6. We request that WGSOCIAL and WGECON assist the group in the identification of metadata relevant to IEA development in the WGEA-WESS region.	WGSOCIAL WGECON