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

11–15 February 2013

Lisbon, Portugal

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CIEM Conseil International pour l'Exploration de la Mer

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Executive summary

The Working Group on Ecosystem Assessment of Western European Shelf Seas (WGEAWESS) met in Lisbon, Portugal from 11 – 15 February 2013. The meeting was co-Chaired by Dr.Maria de Fatima Borges (Portugal) and Dr. Enrique Nogueira (Spain). Apologies were accepted from the co-chair Prof Dave Reid who could not attend this meeting. There were 13 participants representing 7 nations. WGEAWESS is a working group which works to develop the science-base for Integrated Ecosystem Assessments (IEA) in the Western of European Shelf Seas. The group works towards this goal in cooperation with similar groups within the ICES SCICOM Steering Group on the Regional Seas Programme (SSGRSP). The broad objectives of the group are i. to develop and inform links between ecosystem assessment objectives and operational monitoring requirements, ii. to develop approaches and use of models to inform on the possible outcomes of management actions at the ecosystem level and iii. to coordinate and contribute to the preparation of ecosystem overviews to inform management advice. An important output of this meeting was the establishment of a 'core' set of ecosystem variables/components covering a range of industrial sector, human activities and pressures. The data associated with this list should be operationally updated and assessed annually by WGEAWESS so as to provide the necessary input to the ecosystem overviews required by ICES for advice.

1 Opening of the meeting

The 2013 meeting of WGEAWESS was organized back-to-back with the Working Group on Integrated Assessments of the North Sea (WGINOSE). The meeting was kindly hosted by the Instituto Português do Mar e da Atmosfera, I.P (IPMA) in Lisbon, Portugal, from 11th to 15th February, 2013. Participants of the meeting (Annex 1) were welcomed by Dr A. Kenny (co-Chair of WGINOSE) and Dr. M. F. Borges (Co-Chair of WGEAWESS). The agenda for WGEAWESS, including the joint sessions with WGINOSE, is given in Annex 2. During WGEAWESS agenda days 13-14 February meeting was co-chaired by Dr. Maria de Fatima Borges (Portugal) and Dr. Enrique Nogueira (Spain), co-chair Dr. Pascal Laffargue contributed remotely by webex and skype. Apologies were accepted from the co-chair Prof Dave Reid (Ireland) who unfortunately could not attend this meeting. The first day was devoted to 'keynote' presentations made in plenary to both regional assessment groups concerning initiatives of strategic importance namely;

- Benchmark Assessments of Regional Integrated Ecosystem Assessments (WKBEMIA)
- Ecosystem Overviews (WKECOVER)

Cumulative Effects: Overview of Current Thinking (OSPAR, ICG Cumulative Effects) See WGINOSE report for further details of these presentations: http://www.ices.dk/community/groups/Pages/default.aspx#k=wginose

The last morning was dedicated to present and discuss the outcomes of both groups and future actions. The intermediate 2 days were devoted to WGEAWESS term of references.

2 Adoption of the agenda

The agenda (see Annex 2) was unanimously adopted by the groups after a short discussion.

3 Introduction to the meeting

The EAWESS working group focus on North Atlantic European continental shelf. Regional area of interest includes the Celtic sea , Bay of Biscay and Western Iberia, involving five countries (Ireland, UK, France, Spain and Portugal). The group works towards this goal in cooperation with similar groups within the ICES SCICOM Steering Group on the Regional Seas Programme (SSGRSP).

4 Carry out data review and metadata compilation about relevant ecosystem components and process at the regional scale and carry preliminary evaluation of data and trends (tor a).

This term of reference contains two different steps:

> 1 step -Carry out data review and metadata compilation about relevant ecosystem components and process at the regional scale and,
>
> 2 step- Carry out preliminary evaluation of data and trends.

The first was partially accomplished in 2011 (first meeting) and has to be completed and put into a standardized framework. The group agreed that ODDEM framework it is not far from the one we have selected in 2011 and decided to use this framework from now on.

The second step is more difficult, because it must be related to some topics and objectives (EA indicators, MSFD descriptors, etc).

Basis of ecosystem assessment needs to be constructed from a clear knowledge of each of the ecosystem components and links between them as well as their links with descriptors and/or indicators we try to implement. A review of the framework this group WGEAWESS followed in 2011 is presented in **Error! Reference source not found.**A and 1B below presenting the natural components and the anthropogenic pressures with the activities previously adopted and documented in last meeting report.

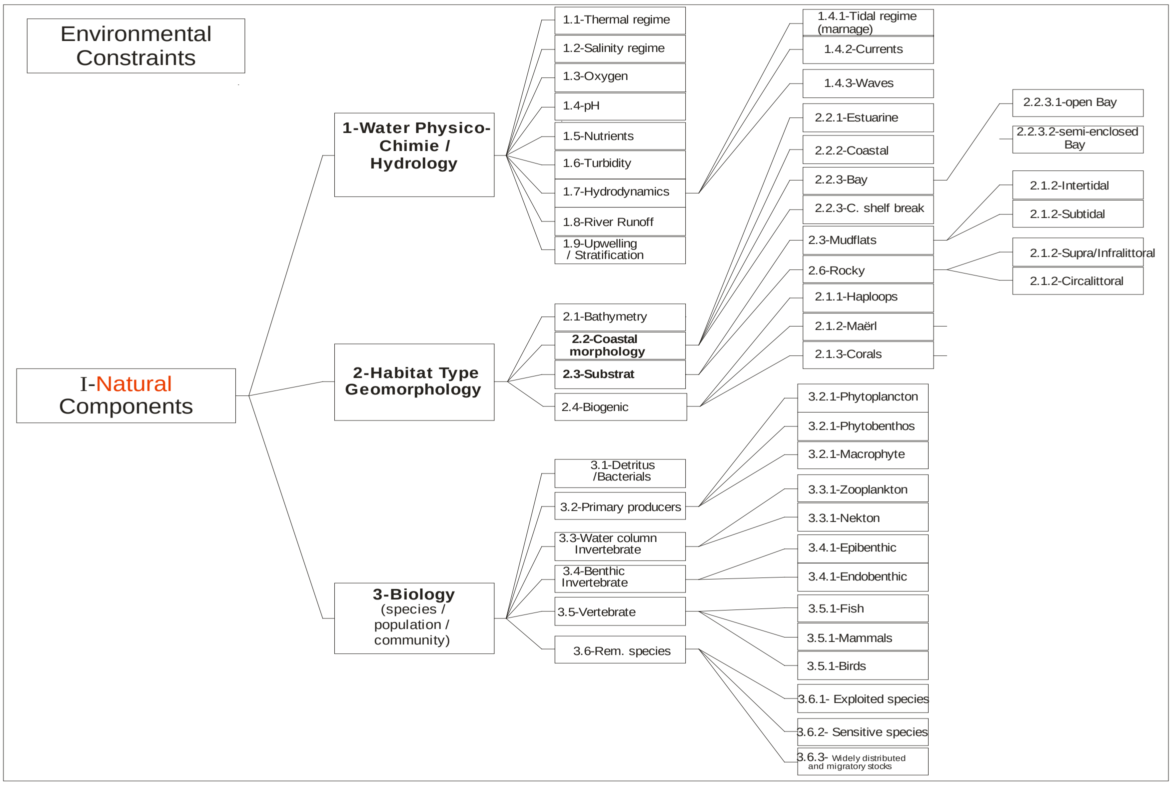

Figure 1a. WGEAWESS approach to the natural components of the ecosystem

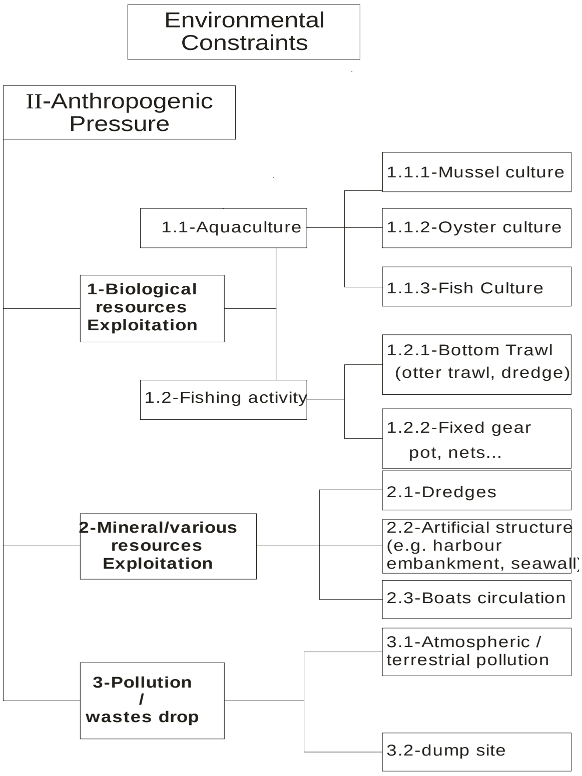

Figure 1b. WGEAWESS approach to the Anthropogenic pressures.

More recently work from EU project ODDEM (http://www.liv.ac.uk/odemm/about_odemm/) and ICES/WKCOVER considered similar frameworks as indicated in the schema below (Figure 1).

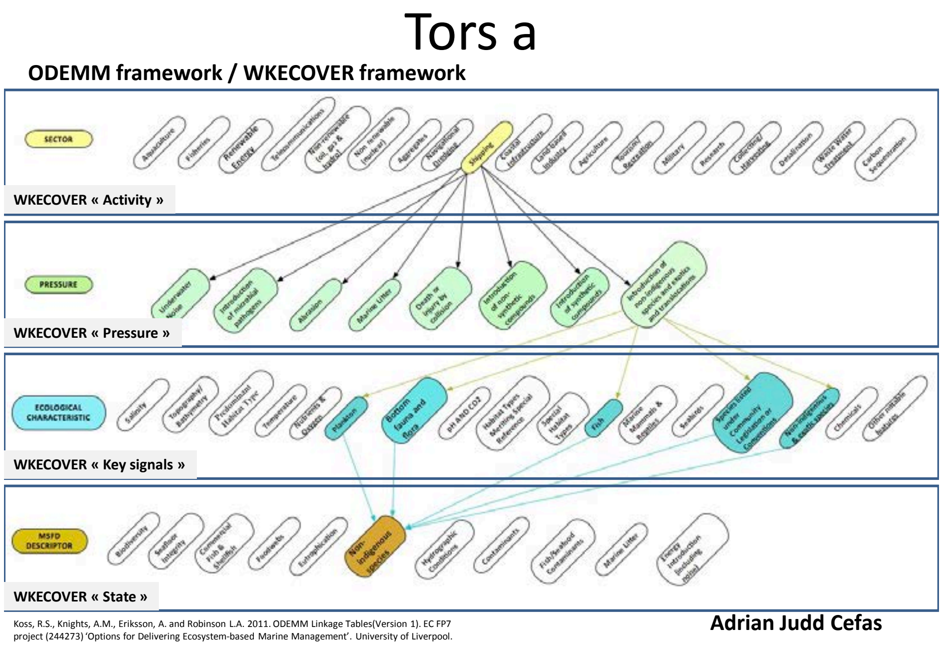

Figure 1. Example of ODDEM framework as proposed into Koss et al. (2001).

ODDEM framework will help us to better formalize links between descriptors (e.g. MSFD or EGS) or indicators and different ecosystems components. Moreover, using that framework will allow us to synthesize and evaluate available data into an indicator or descriptor perspective. Therefore identification of pressure and ecological components that are sufficiently described and those with gaps in available knowledge will be facilitated. Identifying those gaps is of great importance considering the MSFD challenges and needed monitoring approaches. It will especially give better insight on our capability to deliver various indicators or descriptors depending on required data availability, quality and relevance.

We propose to construct a regional "meta-database" based on that framework. Such a database would be implemented depending on new available data and/or new indicators or descriptors needed for different purposes (e.g. MSFD). Completion of that database should be considered as an iterative process and new data or informations will be progressively added from yearly WGEAWESS meetings. We proposed to utilize references tables adapted from that framework. Annex 4 presents and exemplifies the application of the framework (list of codifications is in Table 1 to Table 3 of Annex 4).

From that framework and a dedicated R-script, generic linkages could be evaluated at each component level. Examples of such network structure (e.g. Figure 3) are given for different components groups in Annex 4 as well as a summary of the linkages depending on the component types (Annex 4 Figure 1ab).

In the context of the second step a presentation to the group was sent by Pierre Petigas, Ifremer with the title “Assessment of changes in the ecosystem : a necessary step towards” describing a method to implement an alert system for detecting changes in series of indicators and series of maps: Decision-Cusum control charts and using the traffic light approach to summarize information on significant changes. Annex 5 presents this contribution based in the received presentation.

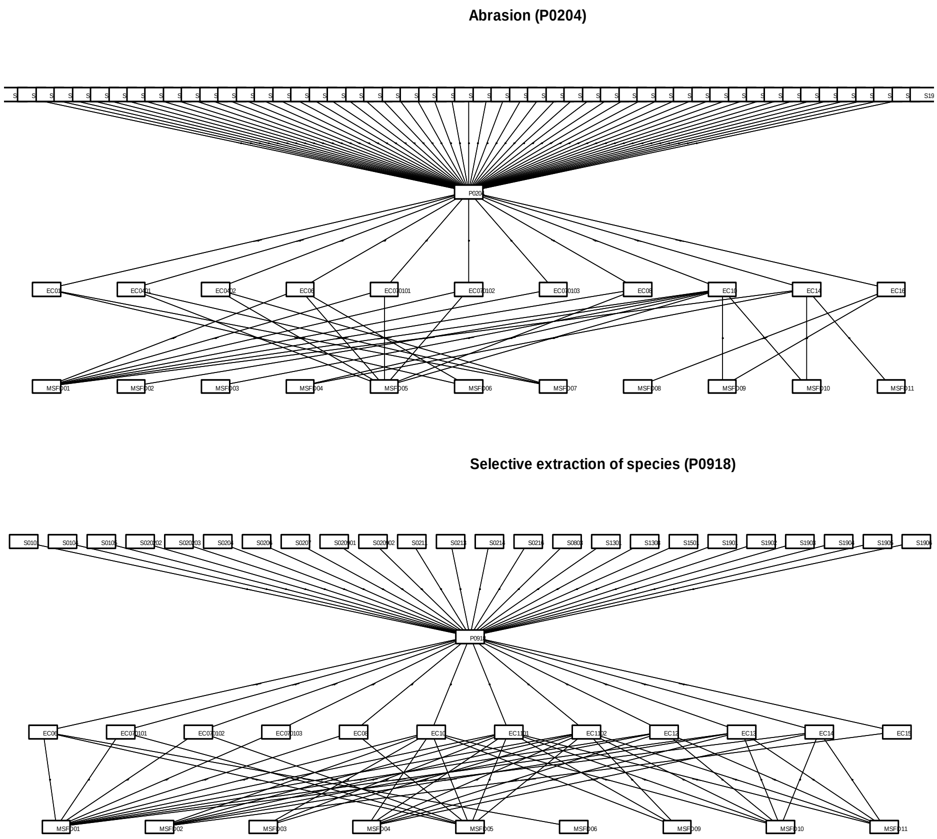

Figure 2. linkages network as derived from adapted ODDEM framework for two pressure components (Abrasion – top ; Selective extraction of species – bottom). Described linkages include sector (S), ecological (EC) groups of ecosystem components as well as MSFD descriptors (detailed name of each component code is given into Annex 4 – Table 1 toTable 3).

5 Review Integrated Ecosystem Assessment methodology and propose appropriate IEA approaches (tor b)

This tor was considered together with tor a in section 4.

6 Based on MSFD pressures/descriptors/indicators combinations, evaluate feasibility and relevance of each of these combinations (tor c)

This tor was considered together with tor a in section 4.

7 Identify potential regional observing assets (both inside and outside ICES) necessary to support development of regional ecosystem assessments (tor d)

In general the existing surveys for monitoring any of the ecosystem components of the region are important assets to support development of regional ecosystem assessments. This subject is discussed in more detail in the report of WGSUR.

Last 2011 WGEAWESS the group presented metadata tables indicating the available observational assets in by sub- region. These tables on data availability should to be updated by the group in connection with the work of WGSUR, ICES WGGOOFE and WGDIG. There is a need to the SCICOM Steering Group on the Regional Seas Programme (SSGRSP) to interlink these groups and discuss in the context of regional IEA metadata availability and possible storage in connection with ICES data center.

A presentation was given by Bee Berx from the ICES Working Group on Operational Oceanographic products for Fisheries and Environment (WGOOFE) on *Connecting the ICES user community to producers of operational oceanographic data products*. This expert group was created within ICES with the aim of improving the uptake of operational oceanographic data products in ICES science and advice. The presentation provided an overview of the group's work to date, which has focused on identifying user needs within ICES and creating a web-portal to demonstrate current availability of operational oceanographic data products.

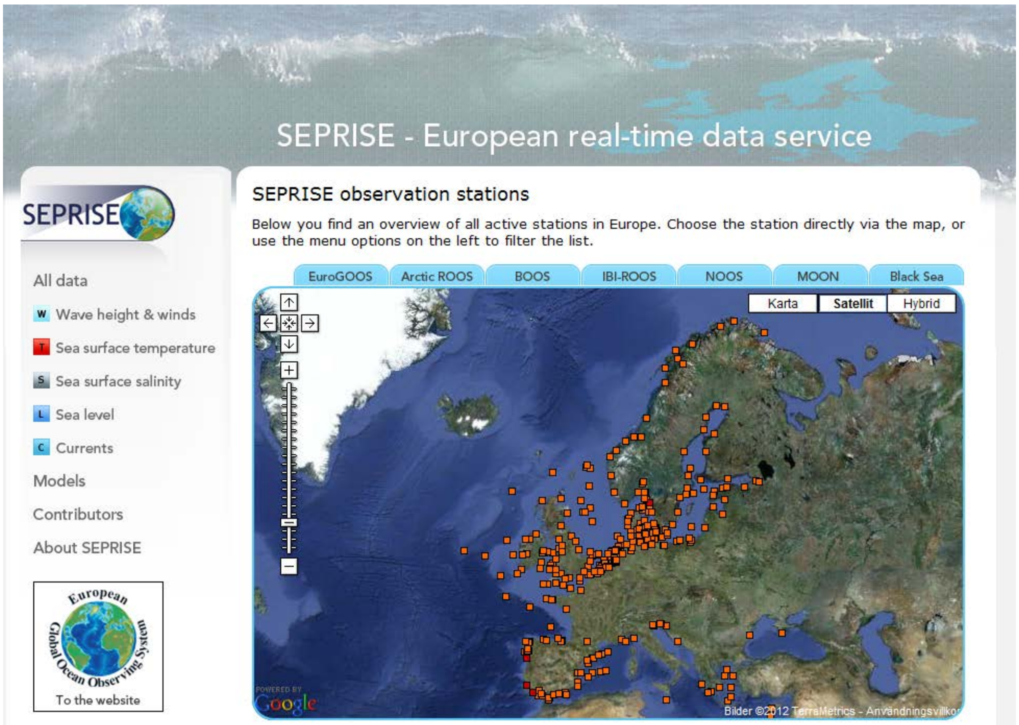

Figure 4 . SEPRISE observational stations.

A demonstration of the WGOOFE portal, which can be found at http://www.wgoofe.org, was given (see Figure 4). The portal also includes an icon for each data product highlighting how easy the product can be accessed. Currently, the WGOOFE is working towards developing further data products with relevance to the ICES community (such as index-based products, e.g.. upwelling indices).

8 Produce an approach for monitoring and developing assessment methods for the top three anthropogenic pressures on ecological characteristics described in the national MSFD reports (submitted in October 2012), for the appropriate regions (tor e).

The group had no time to address this tor.

9 Provide input to ecosystem overviews to provide environmental information to fish stock assessment working groups (tor f)

WGEAWESS reviewed the work of WKECOVER for the region and noted that only the Celtic Sea region was included. On behalf of ICES Mark Dickey-Collas guided the group on the Ecosystem Overviews proposed by WKECOVER. It was agreed to WGEAWESS to work in the ICES required ecosystem overviews in accordance with ICES ecoregions (book of advice regions – Figure 5) are corresponding to:

- Bay of Biscay and Atlantic Iberian Waters;
- Celtic Seas and Western Scotland.

The Group decided to focus only in Sections 1, 2, 3 from the ecosystem overview template, namely the sections addressing; a description of the ecoregion, the key signals and activities and pressures. The updated sections of the Bay of Biscay and Atlantic Iberian Waters ecosystem overview and of the Celtic Seas and Western Scotland ecosystem overviews are presented respectively in Annexes 6 and 7.

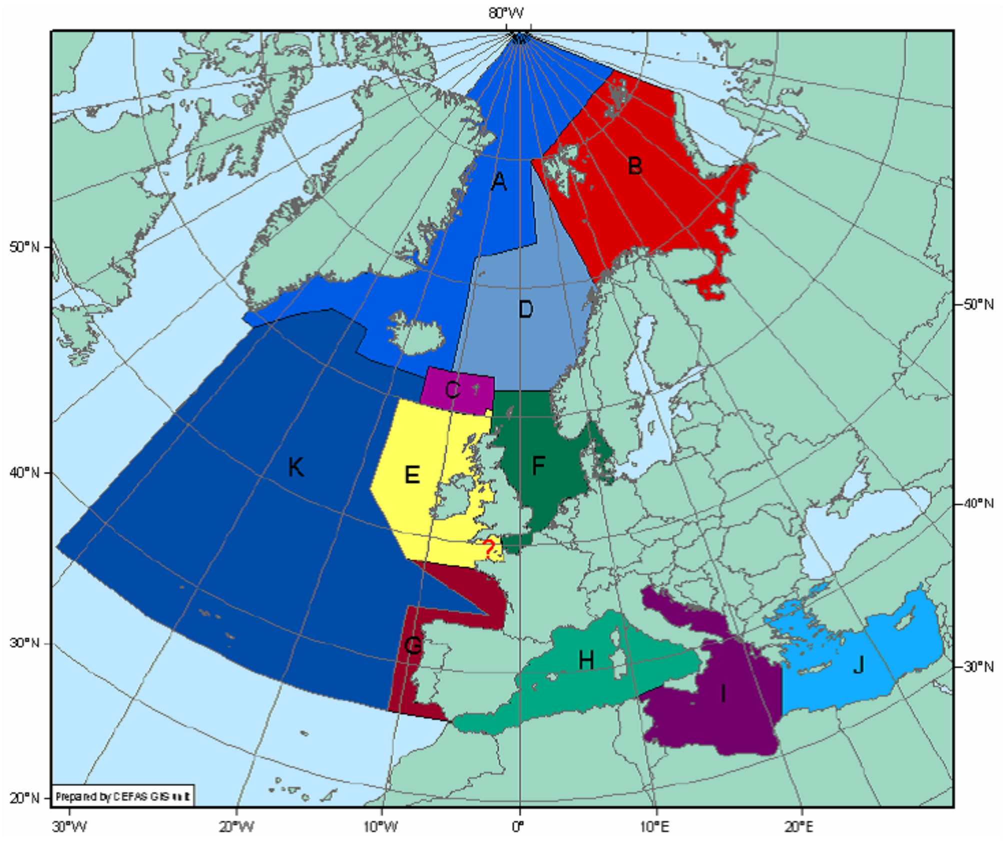

Figure 5. ICES Ecoregions.

In support of the update, especially in relation to the key biotic signals for Bay of Biscay and Atlantic Iberian Waters region, a presentation was made by Enrique Nogueira, IEO, on the "Spatial and temporal characterization of Southern European Atlantic waters based on satellite-derived chlorophyll". Figure 6 below summarizes the main results.

Based on the primary production biotic signals of this region the group decided to adopt four main subregional divisions for simplification: i) Northern Iberia Shelf subregion, ii) Western Iberia subregion, iii) Gulf of Cadiz subregion and iv) Bay of Biscay Shelf, which are used in the ecosystem overview in Annex 6.

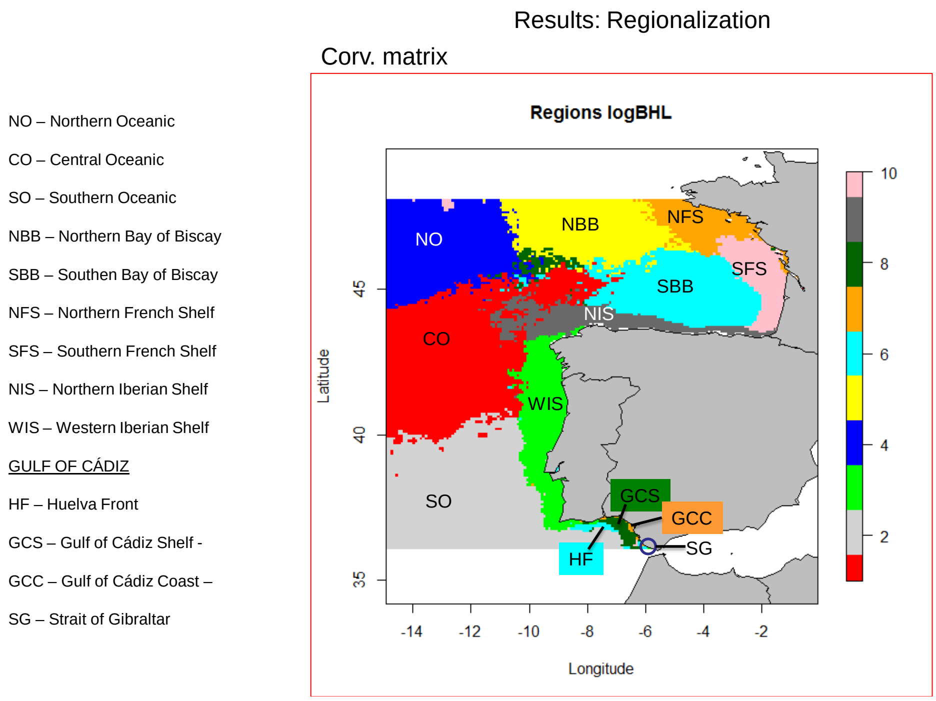

Figure 6 . Spatial and temporal characterization of Southern European Atlantic waters based on satellite-derived chlorophyll. (Enrique Nogueira pers. comm.)

10 Conclusions and Actions

WGEAWESS proposes to construct a regional "meta-database" based on WGEA-WESS/ ODDEM framework as described in Annex 4. Such a database would be implemented depending on new available data and/or new indicators or descriptors needed for different purposes (e.g. MSFD). Completion of that database should be considered as an iterative process and new data or informations will be progressively added from yearly WGEAWESS meetings.

Annex 1: List of participants

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Annex 2: Agenda

ICES Working Group on Ecosystem Assessment of Western European Shelf Seas (WGEAWESS) Lisbon, Portugal 11-15 February 2013
(back-2-back meeting with the ICES WGINOSE

Monday 11 February

13.00 Opening – joint plenary session WGEAWESS and WGINOSE
13.05 Welcome to IPMA (*MFB, House Keeping*)
13.15 Tour de Table
13.30 Joint session objectives and organization (*AK, MFB*)
13.45 Benchmark workshop on IEAs (WKBEMIA) (*MD-c*)
14.30 Ecosystem overviews (WKECOVER) (*AK*)
15.15 OSPAR ICG Cumulative Effects – "Cumulative Effects: Overview of Current Thinking" (*AJ*)
16.00 Coffee
16.30 General discussion – way forward for ICES Regional Assessment WG's (*MD-c, AK,MFB)*
17.30 Close

Tuesday 12 February

09.00 Introduction to WGEAWESS ToRs and organization of meeting agenda (MFB,EN, *by WEBEX - PL,DR*)
09.10 ToR b (IEA modelling tools) – joint session with WGINOSE
North Sea BBN – *Ulrich Callies*
North Sea tGAM- *Marcos Llope*
10.30 *Coffee*
Discussion on links with cumulative effects assesment (ToR c WGEAWESS) (ToR e WGINOSE)
12.30 Lunch
14.00 ToR a - Carry out data review and metadata compilation about relevant ecosystem components and process at the regional scale and carry out preliminary evaluation of data and trends:
15.00 Tea/coffee
ToR d - Identify potential regional observing assets (both inside and outside ICES) necessary to support development of regional ecosystems assessments:
ToR f - Provide input to ecosystem overviews to provide environmental information to fish stock assessment working groups:
17.30 Close

Wednesday 13 February

09.00 Introduction to day (*MFB*)
09.10 ToR c - Based on MSFD pressures/descriptions/indicators combinations evaluate feasibility and relevance of each of these combinations
10.30 Coffee
11.20 ToR e - Produce an approach for monitoring and developing assessment methods for the top three anthropogenic pressures on ecological characteristics described in the national MSFD reports (submitted in October 2012) for the appropriate regions;
12.30 Lunch
14.00 Subgroup working/drafting (*agree subgroup leads*)

15.00 Tea/coffee
15.30 Subgroup initial reports to plenary (c. 10 minutes each) (*subgroup leads*)
16.10 Subgroup working/drafting
17.30 Close
19.00 Workshop Dinner

Thursday 14 February

09.00 Introduction to day (*MFB*)
09.10 ToR a (update on WESS ecosystem overviews)

10.30 Coffee
Subgroup working/drafting (agree *subgroup leads)*
12.30 Lunch
14.00 Subgroup working/drafting
15.00 Tea/coffee
15.30 Review of report
16.50 Reflections on progress and issues to address (*MFB,EN,by PL-webex*)
17.00 Close

Friday 15 February

09.00 Joint plenary session WGEAWESS and WGINOSE (*AK,MFB,EN*)
09.10 Highlights of WGINOSE outcomes – future actions (*AK*)
10.30 Coffee
11.00 Highlights of WGEAWESS outcomes – future actions (*MFB,EN, PL(webex*)
12.30 Plenary discussion
13.00 Close

Annex 3: WGEAWESS terms of reference for the next meeting

The Working Group on Ecosystem Assessment of Western European Shelf Seas (WGEAWESS), chaired by and Enrique Nogueira*, Spain, Dave Reid*, Ireland; Pascal Laffargue*, France, Maria de Fatima Borges, Portugal,

will meet on the 17-21 February 2014 at IEO Gijón, Spain to:

a) Carry out metadata compilation about the ecosystem components according to ODDEM framework;

b) Carry out preliminary evaluation of data and trends for a regional Integrated Ecosystem Assessment;

c) Summarize and update the regional Ecosystem overviews.

WGEAWESS will report (via SSGRSP) by 1 August 2014 for the attention of SCICOM.

Supporting information

Priority	Heavy pressure on shelf seas (biodiversity loss, climate changes, fisheries), lack in understanding of large marine ecosystem functioning and the context of ecosystem health indicators development for the Marine Strategy Framework Directive require to address those research topics at the relevant scale i.e. the regional approach.
Scientific justification	Topics at ecosystem/regional scale need interdisciplinary work dealing with physics and biology coupling to develop descriptive framework an models and to establish functional connexions from smallest to largest scales. Each relevant spatial and temporal observation scales requires developing and sharing observation tools and data sources, ensure data storage and management, specific methodology for data aggregation an use in modelling and indicators developments. Such regional and ecosystemic approaches are needed to study differential, hierarchical an synergetic effects of naturalvs.human pressure on marine ecosystem. The EAWESS working group will focus on North Atlantic European continental shelf. Regional area of interest includes the Celtic sea, bay of Biscay and Western Iberia, involving five countries (Ireland, UK, France, Spain and Portugal). The choose of such limits is justified by : bio-geographical (transitional region between subtropical and Subarctic gyres) chemo-physical continuum: large opened and connected areas dominated by soft bottom, closely linked by regional ocean circulation process, offering 'coast-shelf-slope' and latitudinal environmental gradient management unit (ICES, OSPAR) already existing scientific networks (e.g. IBI-ROOS)
Resource requirements	There is no resource implication for ICES. Working group program is based on synthesis of data and results from existing scientific program, and coordination of surveys and observations networks. However, involvement of ICES data center would useful to help with sharing and harmonizing data..
Participants	20-25 members, 3 chairs
Secretariat facilities	Preparation and dissemination of annual and specific/thematic reports

Financial	No financial implications.
Linkages to advisory committees	Initially there will be no direct linkages with advisory committees, but the integrated approach is expected to support development of ecosystem health indicators and therefore advices on Northeast Atlantic seas management. The group will maintain communication with ACOM vice-chairs for ecosystems..
Linkages to other committees or groups	Natural and strong links will developed with a number of ICES working groups. First of them under the Steering Group on Regional Seas in order to shar and harmonize data and methodology : WGIAB (Integrated Assessments of the Baltic Sea) WGNARS (Working Group on the Northwest Atlantic Regional Sea) Others links within ICES are expected, Observation Networks: IBI-ROOS (Iberian Biscay Irish maritime area – Regional Operational Oceanographic System): Operational oceanography network, real-time data products and services ICES-GOOS (Global Ocean Observing System): Steering Group and Transition Group for the development of ecosystem surveys Steering Group on Ecosystem Surveys and Sampling Technology. Global/integrated ecosystem assessment: WGINOSE (Working Group on Integrated Assessments of the North Sea): multi scales integration, data review in North Atlantic area, quantification of naturalvs.human pressure WGECO WGOOFE
Linkages to other organizations	OSPAR EEA

Annex 4: ODDEM Framework

Table 1. Component codification for anthropogenic sectors (S). List of components is adapted from ODDEM framework.

CODE	DETAIL	CODE parent
S	Sector	
S01	Aquaculture	S
S0101	Finfish - set-up (atmospheric emissions for transport of broodstock/juveniles, interaction with seabed during set-up of infrastructure, loss of gear)	S01
S0102	Finfish - operational (waste products, antifouling, predator control, disease and disease control, infrastructure effects on local hydrography, escapees, litter, anchoring/mooring of boats)	S01
S0103	Macroalgae - set-up (atmospheric emissions from boats (certain species), trampling (certain species), interaction with seabed, removal of habitat-structuring species, loss of gear)	S01
S0104	Macroalgae - operational (waste products, antifouling, predator control, disease and disease control, infrastructure effects on local hydrography, litter, anchoring/mooring of boats)	S01
S0105	Shellfish - setup (atmospheric emissions from boats, interaction with seabed when dredging for broodstock, loss of gear, litter)	S01
S0106	Shellfish - operational (waste products, antifouling, predator control, disease and disease control, infrastructure effects on local hydrography, litter, anchoring/mooring of boats)	S01
S02	Fishing	S
S0201	Benthic trawls and dredges - steaming (atmospheric emissions, collisions)	S02
S0202	Benthic trawls and dredges - operations (interaction with seabed, catch, bycatch, waste products)	S02
S020201	Benthic trawls and dredges - operations-interaction with seabed	S0202
S020202	Benthic trawls and dredges - operations-catch	S0202
S020203	Benthic trawls and dredges - operations-bycatch	S0202
S0203	Benthic trawls and dredges - mooring/anchoring (interaction with seabed)	S02
S0204	Benthic trawls and dredges - general (antifouling, ballast water, litter, lost gear)	S02
S0205	Nets (fixed/set/gillnets/other nets/lines) - set up/recovery (interaction with seabed)	S02

CODE	DETAIL	CODE parent
S0206	Nets (fixed/set/gillnets/other nets/lines) - operational (catch, bycatch, waste products)	S02
S0207	Nets (fixed/set/gillnets/other nets/lines) - general (litter, lost gear, antifoulants)	S02
S0208	Pelagic trawls - steaming (atmospheric emissions, collisions)	S02
S0209	Pelagic trawls - operations (catch, bycatch, waste products)	S02
S020901	Pelagic trawls - operations-catch	S0209
S020902	Pelagic trawls - operations-bycatch	S0209
S020903	Pelagic trawls - operations-waste products	S0209
S0210	Pelagic trawls - mooring/anchoring (interaction with seabed)	S02
S0211	Pelagic trawls - general (antifouling, ballast water, litter, lost gear)	S02
S0212	Potting/creeling - set up/recovery (interaction with seabed)	S02
S0213	Potting/creeling - operational (catch, bycatch, waste products)	S02
S0214	Potting/creeling - general (litter, lost gear)	S02
S0215	Suction/hydraulic dredges - steaming (atmospheric emissions, collisions)	S02
S0216	Suction/hydraulic dredges - operations (interaction with seabed, catch, bycatch, waste products)	S02
S0217	Suction/hydraulic dredges - mooring/anchoring (interaction with seabed)	S02
S0218	Suction/hydraulic dredges - general (antifouling, ballast water, litter, lost gear)	S02
S03	Shipping	S
S0301	Mooring/anchoring/beaching/launching (interaction with seabed)	S03
S0302	Steaming (atmospheric emissions, collisions)	S03
S0303	General (antifouling, ballast water exchange, litter)	S03
S04	Renewable Energy	S
S0401	Wind farms - construction (installation of turbines on seabed includes interaction with seabed, habitat change and sealing, laying cables)	S04
S0402	Wind farms - operational (active cables on seabed - electromagnetic changes, moving turbines - collisions)	S04

CODE	DETAIL	CODE parent
S0403	Wave energy - construction (cable laying - localized habitat change, noise)	S04
S0404	Wave energy - operational (localized electro-magnetic changes around cables, localized change in flow of water)	S04
S0405	Tidal sluices - construction (interaction with seabed, localized sealing of habitat)	S04
S0406	Tidal sluices - operational (localized changes in hydrography)	S04
S0407	Tidal barrages - construction (interaction with seabed, habitat change (upstream and downstream) and localized sealing of habitat, barrier to movement for migratory anhadromous or catadromous species)	S04
S0408	Tidal barrages - operational (change in tidal (and emergence) regime, barrier to movement for migratory anhadromous or catadromous species)	S04
S05	Non-renewable Energy (oil, gas and hydro)	S
S0501	Oil and Gas - exploration (seismic surveys, exploratory drilling and anchoring, oil spills)	S05
S0502	Oil and Gas - construction (drilling, anchoring, construction of wellheads, laying pipelines, oil spills)	S05
S0503	Oil and Gas - operational (waste fluids and particulates to seabed, surface litter and wastewater, oil spills)	S05
S0504	Oil and Gas - decommissioning (anchoring, oil spills, removal of infrastructure where relevant)	S05
S0505	Hydro - operational (barrier to movement for migratory anhadromous or catadromous species, changes in flow regimes in estuaries)	S05
S0506	Power stations (land-based on coast) - construction (jetties and intake wells - habitat change, sealing, increased turbidity, noise)	S05
S0507	Power stations (land-based) - operational (atmospheric emissions, abstraction of water, thermal discharge of cooling water, localized effects on hydrography)	S05
S06	Non-renewable Energy (Nuclear)	S
S0601	Power stations (land-based on coast) - construction (jetties and intake wells - habitat change, sealing, increased turbidity, noise)	S06
S0602	Power stations (land-based) - operational (atmospheric emissions, abstraction of water, thermal discharge of cooling water, localized effects on hydrography)	S06
S07	Telecommunications	S
S0701	Communication cables - laying cables (localized habitat change and smothering, interaction with seabed, atmospheric emissions from ships laying cables)	S07
S0702	Communication cables - active operational (localized electro-magnetic changes)	S07
S08	Aggregates	S
S0801	Inorganic mine and particulate waste - extraction of substratum (habitat change, interaction with seabed)	S08
S0802	Inorganic mine and particulate waste - spoil/waste disposal (habitat change, smothering)	S08

CODE	DETAIL	CODE parent
S0803	Maerl - extraction of substratum (habitat change, interaction with seabed, removal of habitat-structuring species)	S08
S0804	Maerl - spoil/waste disposal (habitat change, smothering)	S08
S0805	Rock/Minerals - coastal quarrying - extraction of substratum (habitat change, interaction with seabed, contaminant release)	S08
S0806	Rock/Minerals - coastal quarrying - spoil/waste disposal (habitat change, smothering)	S08
S0807	Sand/gravel aggregates - extraction of substratum (habitat change, interaction with seabed, contaminant release)	S08
S0808	Sand/gravel aggregates - spoil/waste disposal (habitat change, smothering)	S08
S09	Navigational Dredging	S
S0901	Capital dredging - extraction of substratum (habitat change, interaction with seabed, contaminant release, increased turbidity, noise)	S09
S0902	Capital dredging - spoil/waste disposal (habitat change, smothering)	S09
S0903	Maintenance dredging - extraction of substratum (habitat change, interaction with seabed, contaminant release, increased turbidity, noise)	S09
S0904	Maintenance dredging - spoil/waste disposal (habitat change, smothering)	S09
S10	Coastal Infrastructure	S
S1001	Artificial reefs - construction (interaction with seabed, habitat change)	S10
S1002	Artificial reefs - operational (localized changes in hydrography, visual cues)	S10
S1003	Beach replenishment - operational (habitat change, smothering, contaminants (depends on nature of material added))	S10
S1004	Culverting lagoons - construction (interaction with seabed, habitat change, smothering, increased turbidity, noise)	S10
S1005	Culverting lagoons - operational (localized changes in hydrography)	S10
S1006	Marinas and dock/port facilities - construction (habitat change, sealing, interaction with seabed, smothering, increased turbidity, noise)	S10
S1007	Marinas and dock/port facilities - operational (antifouling, contaminants, interaction with seabed from anchoring, litter)	S10
S1008	Land claim - construction (habitat change, smothering, increased turbidity, noise)	S10
S1009	Land claim - operational (localized changes in hydrography)	S10
S1010	Coastal defence - Sea walls/breakwaters/groynes - construction (habitat change, sealing, interaction with seabed, smothering, increased turbidity, noise)	S10
S1011	Coastal defence - Sea walls/breakwaters/groynes - operational (loalised changes in hydrography and sediment distribution)	S10

CODE	DETAIL	CODE parent
S11	Land-based Industry	S
S1101	Industry with discharges into rivers and coastal waters - operational (Industrial effluent discharge, abstraction of water)	S11
S1102	All industry - operational (atmospheric emissions)	S11
S12	Agriculture	S
S1201	Deforestation (contribution to climate change)	S12
S1202	General (atmospheric emissions, run-off of nutrients)	S12
S13	Tourism/Recreation	S
S1301	Angling (catch, bycatch, interaction with seabed (gear, and anchors if offshore))	S13
S1302	Boating/Yachting - steaming (collisions)	S13
S1303	Boating/Yachting - mooring/anchoring/beaching/launching (interaction with seabed)	S13
S1304	Boating/Yachting - general (antifouling, ballast water exchange, litter)	S13
S1305	Diving/Dive site - steaming (collisions)	S13
S1306	Diving/Dive site - mooring/anchoring/beaching/launching (interaction with seabed)	S13
S1307	Diving/Dive site - general (antifouling, litter)	S13
S1308	Diving/Dive site - operations (trampling, spp extraction)	S13
S1309	Public beach - general (trampling, litter)	S13
S1310	Tourist Resort - construction (habitat change, sealing, smothering, increased turbidity, noise)	S13
S1311	Tourist Resort - operational (effluent discharge, abstraction fo water, litter)	S13
S1312	Water sports - mooring/anchoring/beaching/launching (interaction with seabed)	S13
S1313	Water sports - steaming (collisions)	S13
S14	Military	S
S1401	Operations (specific to activity but can include: seismic activities, sonar)	S14
S1402	Mooring/anchoring/beaching/launching (interaction with seabed)	S14

CODE	DETAIL	CODE parent
S1403	General (antifouling, ballast water exchange, litter)	S14
S1404	Steaming (atmospheric emissions, collisions)	S14
S15	Research	S
S1501	Operations (specific to activity but can include: interaction with seabed, catch, bycatch)	S15
S1502	Mooring/anchoring/beaching/launching (interaction with seabed)	S15
S1503	General (antifouling, ballast water exchange, litter)	S15
S1504	Steaming (atmospheric emissions, collisions)	S15
S16	Desalination	S
S1601	Operational (effluent discharge, abstraction of water)	S16
S17	Wastewater Treatment	S
S1701	Operational (effluent discharge, thermal discharge)	S17
S18	Carbon sequestration	S
S1801	Exploration (interaction with seabed, anchoring, drilling)	S18
S1802	Construction (drilling, habitat change, localized sealing)	S18
S1803	Operational (effects on local chemical composition of water?, atmospheric emissions from transport ships)	S18
S19	Harvesting/Collecting	S
S1901	Bait digging - (trampling, interaction with seabed, removal of habitat-structuring species)	S19
S1902	Seaweed and saltmarsh vegetation harvesting - (trampling, interaction with seabed, removal of habitat-structuring species)	S19
S1903	Bird eggs - (trampling, removal of individuals)	S19
S1904	Shellfish hand collecting - (trampling, interaction with seabed, removal of individuals)	S19
S1905	Peels (boulder turning) - (trampling, removal of individuals)	S19
S1906	Curios - (trampling)	S19

Table 2. Component codification for pressures (P).

CODE	DETAIL	CODEparent
P	Pressure	
P01	Physical loss	P
P0101	Smothering	P01
P0102	SubstratumLoss	P01
P02	Physical damage	P
P0203	Changesinsiltation	P02
P0204	Abrasion	P02
P0205	SelectiveExtraction of Non-living Resources	P02
P03	Other physical disturbance	P
P0306	Underwater noise	P03
P0307	Marine Litter	P03
P04	Interference with hydrological processes	P
P0408	Thermal regime changes	P04
P05	Interference with chemical composition of water	P
P0509	Salinity regime changes	P05
P06	Contamination by hazardous substances	P
P0610	Introduction of Synthetic compounds	P06
P0611	Introduction of Non-synthetic compounds	P06
P0612	Introduction of Radionuclides	P06
P07	Systematic and/or intentional release of substances	P
P0713	Introduction of other substances	P07
P08	Nutrient and organic matter enrichment	P

P0814	Nitrogen and Phosphorus enrichment	P08
P0815	Input of organic matter	P08
P09	Biological disturbance	P
P0916	Introduction of microbial pathogens	P09
P0917	Introduction of non-indigenous spp	P09
P0918	Selective extraction of species	P09
P0919	Death or injury by collision	P09
P0920	Barrier to species movement	P09
P10	Interference with hydrological processes	P
P1021	Emergence regime change	P10
P1022	rate changes	P10
P1025	Change in wave exposure	P10
P11	Interference with chemical composition of water	P
P1123	pH changes	P10
P1124	Electromagnetic changes	P10

Table 3. Component codification for ecological characteristics (EC)

CODE	DETAIL	CODEparent
EC	Ecological Characteristic	
EC01	Topography and Bathymetry	EC
EC02	Temperature	EC
EC03	Salinity	EC
EC04	Nutrients and Oxygen	EC
EC0401	Nutrients	EC04
EC0402	Oxygen	EC04
EC05	pH and pCO2	EC
EC06	Predominant Habitat	EC
EC07	Special Habitat Type	EC
EC0701	Biogenic habitats	EC07
EC070101	Maërl	EC0701
EC070102	Haploops	EC0701
EC070103	Cold-waterCorals	EC0701
EC08	Habitat Types Meriting Special Reference	EC
EC09	Phyto-zooplankton	EC
EC0901	Phytoplankton	EC
EC0902	zooplankton	EC
EC10	Bottom fauna and flora	EC
EC11	Fish	EC
EC1101	Bentho-demersal	EC11
EC1102	Pelagic	EC11

EC12	Marine mammals and Reptiles	EC
EC13	Seabirds	EC
EC14	Species listed under Community Legislation or Conventions	EC
EC15	Non-indigenous and exotic spp	EC
EC16	Chemicals	EC
EC17	Other notable features	EC
EC18	Turbidity	EC
EC19	Hydrological processes	EC
EC191	Current	EC19
EC192	Wave	EC19
EC193	River runnof	EC19
EC20	Geology	EC
EC2001	Sediments	EC20

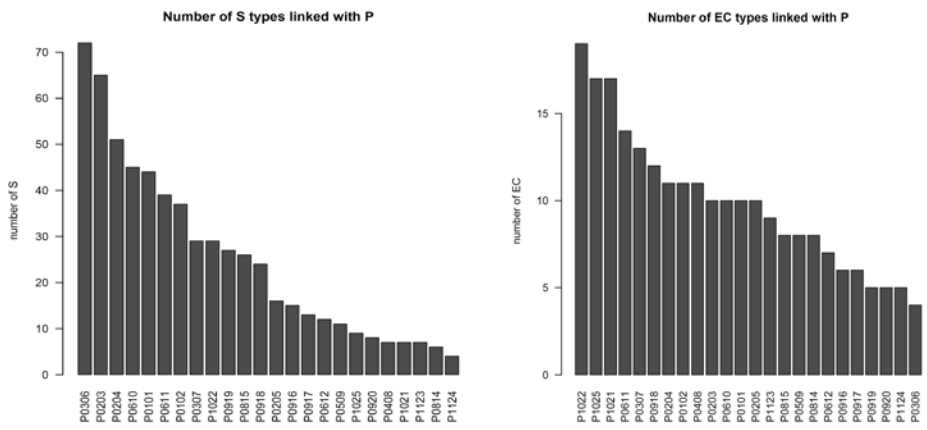


Figure 1a. Number of linkages for one group of components (Pressures (P) and ecological (EC) components). Utilized codes are described into annexes (Table 1 to Table 3).

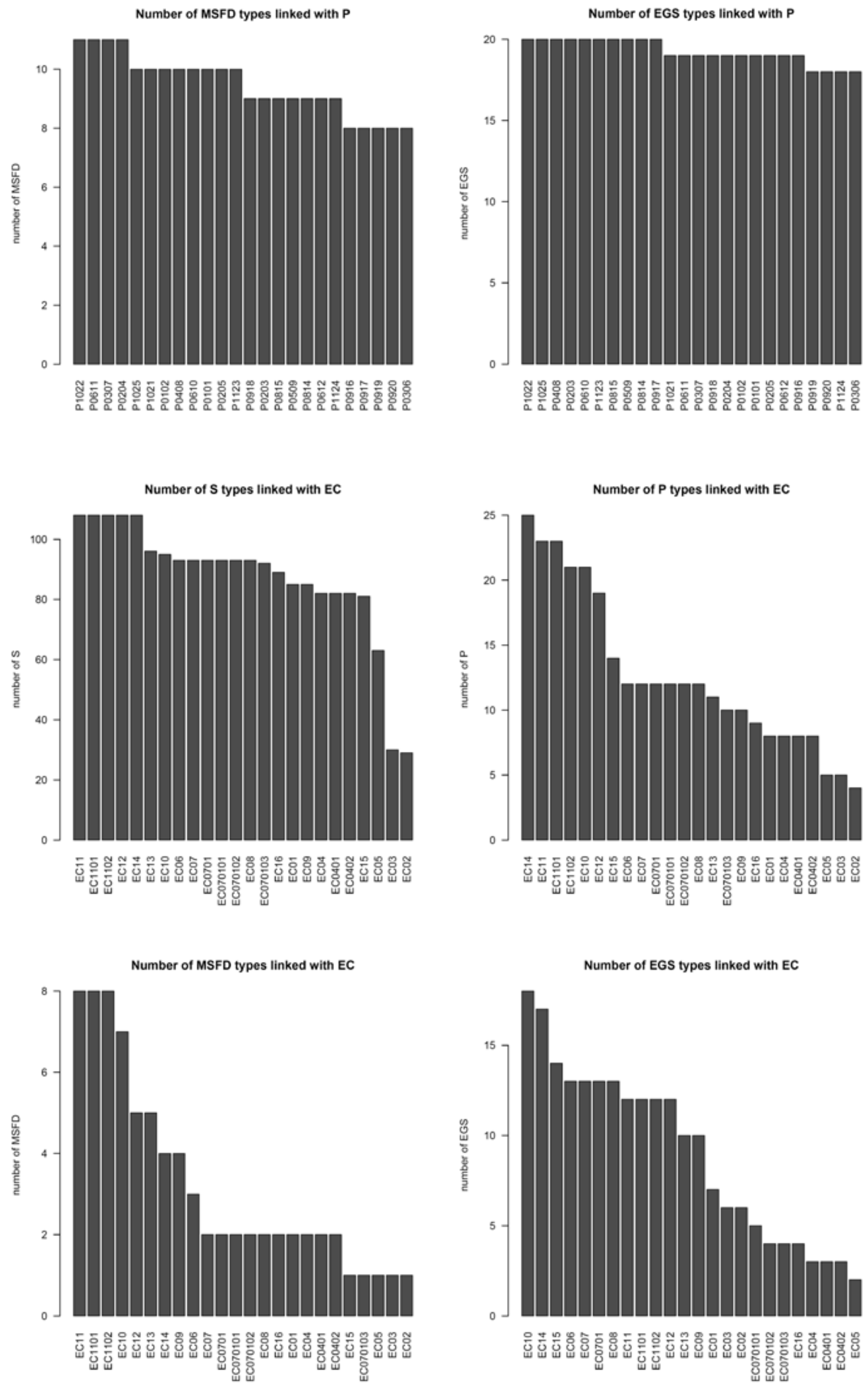


Figure 1b. Number of linkages for one group of components (Figure2B: EC) with sector (S) and ecological (EC) components as well as Marine Strategy Framework Directive (MSFD) and Ecosystem Goods and Services (EGS) descriptors. Utilized codes are described in Table 1 to Table 3.

Some of those indicators or descriptors display very high linkages complexity with a multitude of links at each component level whereas others display lower complexity (e.g. Figure 2). Such differences should be carefully considered as far as that network is highly dependent on the chosen framework itself and that some of the groups and components are better described (i.e. they include more sublevels).

Such framework will help us to evaluate the strength of the linkage and moreover the availability of data to cover the links. It will be closely related to metadata collection table. Linkages with metadata table has to be completed but some examples of data coverage is given into Figure 2 and 3.

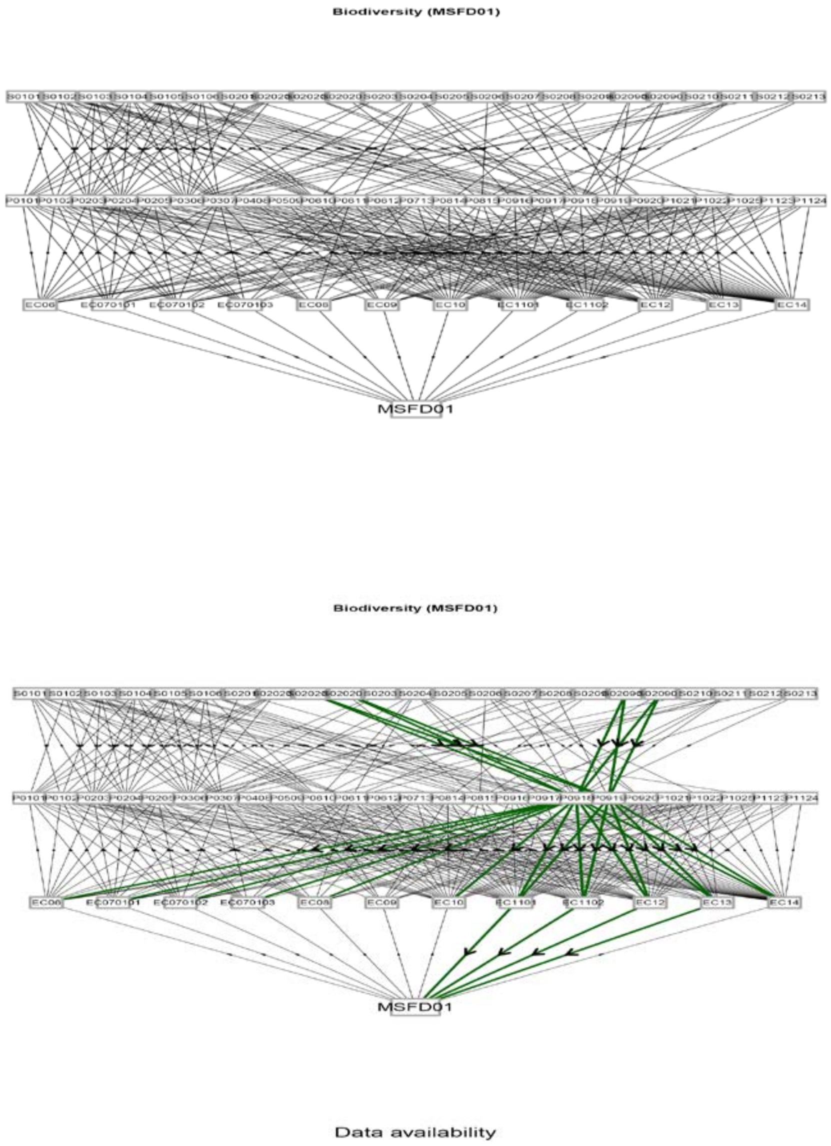


Figure 2. Example of variation in linkages complexity for MSFD descriptors (MSFD01) from the highest available level of description for components: Upper panel indication of linkages only and Lower panel) indications of data availability from upper to lower components (these graphs are theoretical examples only and must be completed to reflect real data availability and relevance).

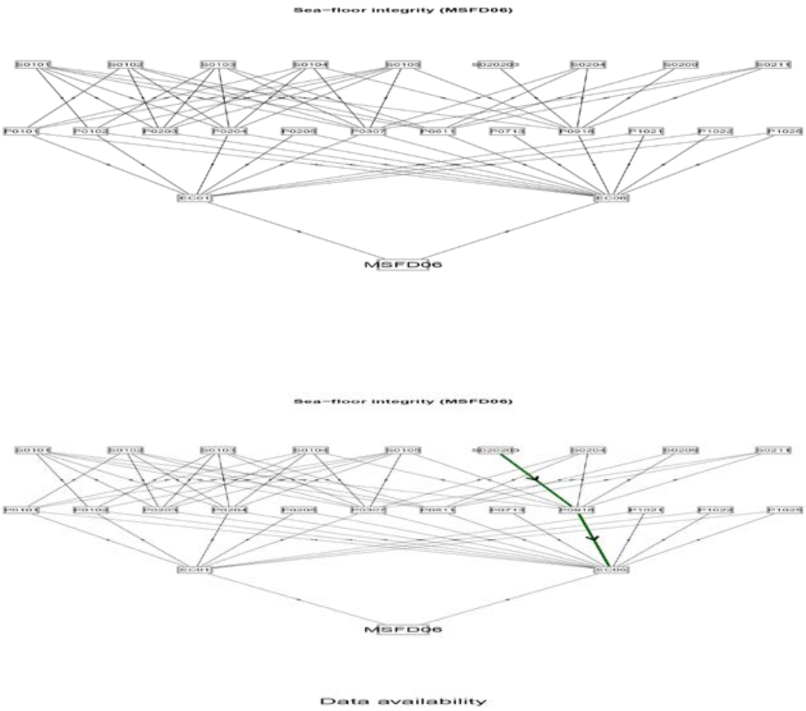


Figure 3. Example of variation in linkages complexity for MSFD descriptors (MSFD06) from the highest available level of description for components: Upper panel indication of linkages only and Lower panel) indications of data availability from upper to lower components (these graphs are theoretical examples only and must be completed to reflect real data availability and relevance).

Table 4. Reference table as adapted from ODDEM framework giving linkages between Sector and pressure groups of components.

Code	P0101	P0102	P0203	P0204	P0205	P0306	P0307	P0408	P0509	P0610	P0611	P0612	P0713	P0814	P0815	P0916	P0917	P0918	P0919	P0920	P1021	P1022	P1025	P1123	P1124
S0101	0	1	1	1	0	1	1	0	0	1	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0
S0102	1	0	1	1	0	1	1	0	0	1	1	0	0	1	1	1	1	0	0	0	0	0	0	1	0
S0103	0	1	1	1	0	1	1	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
S0104	1	0	1	1	0	1	1	0	0	1	0	0	0	0	1	1	1	1	0	0	0	0	0	0	0
S0105	1	1	1	1	0	1	1	0	0	1	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0
S0106	1	0	1	1	0	1	1	0	0	1	0	0	0	0	1	1	1	0	0	0	0	0	0	0	0
S0201	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
S0202	1	1	1	1	0	1	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0
S020201	1	1	1	1	0	1		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
S020202	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0
S020203	0	0	0	0	0	0		0	0	0	0	0	0	0	1	0	0	1	1	0	0	0	0	0	0
S0203	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
S0204	0	0	0	0	0	0	1	0	0	1	1	0	0	0	0	1	1	1	0	0	0	0	0	0	0
S0205	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
S0206	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	1	0	1	0	0	0
S0207	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0
S0208	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
S0209	0	0	0	0	0	1	0	0	0	0	1	0	0	1	1	0	0	1	0	0	0	0	0	0	0
S020901	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0
S020902	0	0	0	0	0	0		0	0	0	0	0	0	0	1	0	0	1	1	0	0	0	0	0	0
S020903																									
S0210	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Code	P0101	P0102	P0203	P0204	P0205	P0306	P0307	P0408	P0509	P0610	P0611	P0612	P0713	P0814	P0815	P0916	P0917	P0918	P0919	P0920	P1021	P1022	P1025	P1123	P1124
S0211	0	0	0	0	0	0	1	0	0	1	1	0	0	0	0	1	1	1	0	0	0	0	0	0	0
S0212	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
S0213	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0
S0214	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
S0215	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
S0216	1	1	1	1	0	1	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0
S0217	0	0	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
S0218	1	0	0	0	0	0	1	0	0	1	1	0	0	0	0	1	1	0	0	0	0	0	0	0	0
S0301	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
S0302	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
S0303	0	0	0	0	0	0	1	0	0	1	1	0	0	0	0	1	1	0	0	0	0	0	0	0	0
S0401	1	1	1	1	0	1	0	0	0	1	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0
S0402	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	1	0	0	1
S0403	1	1	1	1	0	1	0	0	0	1	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0
S0404	0	0	1	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	1	1	0	1
S0405	1	1	1	1	0	1	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
S0406	0	0	1	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	1	1	1	1	1	0	0
S0407	1	1	1	1	0	1	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
S0408	0	0	1	0	1	1	0	0	1	0	0	0	0	0	0	0	0	0	1	1	1	1	1	0	1
S0501	1	1	1	1	1	1	0	0	0	1	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0
S0502	1	1	1	1	0	1	0	0	0	1	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0
S0503	1	0	1	0	1	1	1	0	0	1	1	0	0	0	1	1	0	0	1	0	0	0	0	0	0
S0504	1	0	1	1	0	1	1	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0
S0505	0	0	1	0	1	1	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0

Code	P0101	P0102	P0203	P0204	P0205	P0306	P0307	P0408	P0509	P0610	P0611	P0612	P0713	P0814	P0815	P0916	P0917	P0918	P0919	P0920	P1021	P1022	P1025	P1123	P1124
S0506	1	1	1	1	0	1	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
S0507	0	0	1	0	1	0	0	1	1	1	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0
S0601	1	1	1	1	0	1	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
S0602	0	0	1	0	1	0	0	1	1	1	1	1	0	0	0	0	0	0	0	0	0	1	0	0	0
S0701	1	1	1	1	0	1	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
S0702	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
S0801	1	1	1	1	1	1	0	0	0	1	1	1	0	0	1	0	0	0	0	0	0	1	0	0	0
S0802	1	1	1	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0
S0803	1	1	1	1	0	1	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0
S0804	1	1	1	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
S0805	1	1	1	1	1	1	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0
S0806	1	1	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
S0807	1	1	1	1	1	1	0	0	0	1	1	1	0	0	1	0	0	0	0	0	0	1	0	0	0
S0808	1	1	1	0	0	1	0	0	0	1	1	1	0	0	1	0	0	0	0	0	0	1	0	0	0
S0901	1	1	1	1	1	1	0	0	0	1	1	1	0	0	1	0	0	0	0	0	0	1	0	0	0
S0902	1	1	1	0	0	1	0	0	0	1	1	1	0	0	1	0	0	0	0	0	0	1	0	0	0
S0903	1	1	1	1	1	1	0	0	0	1	1	1	0	0	1	0	0	0	0	0	0	1	0	0	0
S0904	1	1	1	0	0	1	0	0	0	1	1	1	0	0	1	0	0	0	0	0	0	1	0	0	0
S1001	1	1	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
S1002	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0
S1003	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0
S1004	1	1	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
S1005	0	0	1	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0
S1006	1	1	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Code	P0101	P0102	P0203	P0204	P0205	P0306	P0307	P0408	P0509	P0610	P0611	P0612	P0713	P0814	P0815	P0916	P0917	P0918	P0919	P0920	P1021	P1022	P1025	P1123	P1124
S1007	0	0	1	1	0	1	1	1	1	1	0	0	0	0	0	1	1	0	0	0	0	1	0	0	0
S1008	1	1	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
S1009	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0
S1010	1	1	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
S1011	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0
S1101	0	0	1	0	0	0	1	1	1	1	1	1	0	1	0	1	0	0	0	0	0	1	0	1	0
S1102	0	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0
S1201	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
S1202	0	0	1	0	0	0	0	0	1	1	1	0	0	1	1	1	0	0	0	0	0	1	0	1	0
S1301	0	0	0	1	0	1	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
S1302	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
S1303	0	0	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
S1304	0	0	0	0	0	0	1	0	0	1	1	0	0	0	1	0	1	0	0	0	0	0	0	0	0
S1305	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
S1306	0	0	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
S1307	0	0	0	0	0	0	1	0	0	1	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0
S1308	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
S1309	0	0	0	1	0	1	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
S1310	1	1	1	1	0	1	1	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
S1311	1	0	1	0	1	0	1	0	0	1	1	0	0	1	1	1	0	0	0	0	0	1	0	1	0
S1312	0	0	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
S1313	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
S1401	0	1	1	0	0	1	1	0	0	1	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0

Table 5. Reference table as adapted from ODDEM framework giving linkages between pressure and ecological groups of components (preliminary table, some missing linkages have to be completed).

CODE	EC01	EC02	EC03	EC04	EC0401	EC0402	EC05	EC06	EC07	EC0701	EC070101	EC070102	EC070103	EC08	EC09	EC10	EC11	EC1101	EC1102	EC12	EC13	EC14	EC15	EC16	EC17	EC18	EC19	EC191	EC192	EC193	EC20	EC201
P0101	1	0	0	1	1	1	0	1	1	1	1	1	1	1	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
P0102	1	0	0	0	0	0	0	1	1	1	1	1	1	1	0	1	1	1	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0
P0203	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0
P0204	1	0	0	1	1	1	0	1	1	1	1	1	1	1	0	1	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0
P0205	1	0	0	0	0	0	0	1	1	1	1	1	1	1	0	1	1	1	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0
P0306	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0
P0307	1	0	0	0	0	0	0	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1	0	1	0	0	0	0	0	0	0	0	0
P0408	0	1	0	1	1	1	0	0	0	0	0	0	0	0	1	1	1	1	1	1	0	1	1	1	0	0	0	0	0	0	0	0	0
P0509	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	0	1	1	0	0	0	0	0	0	0	0	0	0
P0610	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0
P0611	0	0	0	0	0	0	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0

CODE	EC01	EC02	EC03	EC04	EC0401	EC0402	EC05	EC06	EC07	EC0701	EC070101	EC070102	EC070103	EC08	EC09	EC10	EC11	EC1101	EC1102	EC12	EC13	EC14	EC15	EC16	EC17	EC18	EC19	EC191	EC192	EC193	EC20	EC2001
P0612	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	0	1	1	1	0	0	0	0	0	0	0	0
P0713	0	0	0	0	0	0	0	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0
P0814	0	0	0	1	1	1	0	0	0	0	0	0	0	0	1	1	1	1	1	0	0	1	1	0	0	0	0	0	0	0	0	0
P0815	0	0	0	1	1	1	0	0	0	0	0	0	0	0	1	1	1	1	1	0	0	1	1	0	0	0	0	0	0	0	0	0
P0916	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0
P0917	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	0	0	1	1	0	0	0	0	0	0	0	0	0
P0918	0	0	0	0	0	0	0	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0
P0919	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0
P0920	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0
P1021	1	1	1	1	1	1	0	1	1	1	1	1	1	1	0	1	1	1	1	1	1				0	0	0	0	0			
P1022	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0
P1123	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	1	1	1	1	1	0	1	1	1	0	0	0	0	0	0	0	0
P1124	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	0	1	0	0	0	0	0	0	0	0	0	0

CODE	EC01	EC02	EC03	EC04	EC0401	EC0402	EC05	EC06	EC07	EC0701	EC070101	EC070102	EC070103	EC08	EC09	EC10	EC11	EC1101	EC1102	EC12	EC13	EC14	EC15	EC16	EC17	EC18	EC19	EC191	EC192	EC193	EC20	EC201
P1025	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1	0	1	1	0	0	0	0	0	0	0	0	0	0

Table 6. Reference table as adapted from ODDEM framework giving linkages between ecological (EC) group of components and Marine Strategy Framework Directive descriptors (MSFD).

CODE	MSFD01	MSFD02	MSFD03	MSFD04	MSFD05	MSFD06	MSFD07	MSFD08	MSFD09	MSFD10	MSFD11
EC	1	1	1	1	1	1	1	1	1	1	1
EC01	0	0	0	0	0	1	1	0	0	0	0
EC02	0	0	0	0	0	0	1	0	0	0	0
EC03	0	0	0	0	0	0	1	0	0	0	0
EC04	0	0	0	0	1	0	1	0	0	0	0
EC0401	0	0	0	0	1	0	1	0	0	0	0
EC0402	0	0	0	0	1	0	1	0	0	0	0
EC05	0	0	0	0	0	0	1	0	0	0	0
EC06	1	0	0	0	1	1	0	0	0	0	0
EC07	1	0	0	0	1	0	0	0	0	0	0
EC0701	1	0	0	0	1	0	0	0	0	0	0
EC070101	1	0	0	0	1	0	0	0	0	0	0
EC070102	1	0	0	0	1	0	0	0	0	0	0
EC070103	1	0	0	0	0	0	0	0	0	0	0
EC08	1	0	0	0	1	0	0	0	0	0	0
EC09	1	1	0	1	1	0	0	0	0	0	0
EC10	1	1	1	1	1	0	0	0	1	1	0
EC11	1	1	1	1	1	0	0	0	1	1	1
EC1101	1	1	1	1	1	0	0	0	1	1	1
EC1102	1	1	1	1	1	0	0	0	1	1	1
EC12	1	1	0	1	0	0	0	0	0	1	1

CODE	MSFD01	MSFD02	MSFD03	MSFD04	MSFD05	MSFD06	MSFD07	MSFD08	MSFD09	MSFD10	MSFD11
EC13	1	1	0	1	0	0	0	0	0	1	1
EC14	1	0	0	1	0	0	0	0	0	1	1
EC15	0	1	0	0	0	0	0	0	0	0	0
EC16	0	0	0	0	0	0	0	1	1	0	0
EC17	0	0	0	0	0	0	0	0	0	0	0
EC18	0	0	0	0	0	0	0	0	0	0	0
EC19	0	0	0	0	0	0	0	0	0	0	0
EC191	0	0	0	0	0	0	0	0	0	0	0
EC192	0	0	0	0	0	0	0	0	0	0	0
EC193	0	0	0	0	0	0	0	0	0	0	0
EC20	0	0	0	0	0	0	0	0	0	0	0
EC201	0	0	0	0	0	0	0	0	0	0	0

Table 7. Reference table as adapted from ODDEM framework giving linkages between ecological (EC) group of components and Ecosystem Goods and Services descriptors (EGS).

CODE	EGS01	EGS02	EGS03	EGS04	EGS05	EGS06	EGS07	EGS08	EGS09	EGS10	EGS11	EGS12	EGS13	EGS14	EGS15	EGS16	EGS17	EGS18	EGS19	EGS20	EGS21
EC01	0	0	0	0	0	0	0	0	1	1	0	1	0	1	0	1	1	0	0	1	0
EC02	0	0	0	0	0	0	0	0	0	1	1	0	0	1	0	1	1	0	0	1	0
EC03	0	0	1	0	0	0	0	0	0	1	0	0	0	1	0	1	1	0	0	1	0
EC04	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	1	0
EC0401	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	1	0
EC0402	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	1	0
EC05	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0
EC06	0	0	1	0	0	1	0	0	1	1	0	1	0	1	1	1	1	1	1	1	1
EC07	0	0	1	0	0	1	0	0	1	1	0	1	0	1	1	1	1	1	1	1	1
EC0701	0	0	1	0	0	1	0	0	1	1	0	1	0	1	1	1	1	1	1	1	1
EC070101	0	0	1	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0	1
EC070102	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0	1
EC070103	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0	1
EC08	0	0	1	0	0	1	0	0	1	1	0	1	0	1	1	1	1	1	1	1	1
EC09	1	0	1	1	1	0	1	1	0	0	1	0	1	0	0	0	0	1	0	1	0
EC10	1	0	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	0	1	1
EC11	1	0	1	1	1	1	0	0	0	0	0	0	1	0	0	1	1	1	1	1	1
EC1101	1	0	1	1	1	1	0	0	0	0	0	0	1	0	0	1	1	1	1	1	1
EC1102	1	0	1	1	1	1	0	0	0	0	0	0	1	0	0	1	1	1	1	1	1
EC12	1	0	1	1	1	1	0	0	0	0	0	0	1	0	0	1	1	1	1	1	1
EC13	1	0	0	1	0	1	0	0	0	0	0	0	1	0	0	1	1	1	1	1	1
EC14	1	0	0	1	1	1	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1

CODE	EGS01	EGS02	EGS03	EGS04	EGS05	EGS06	EGS07	EGS08	EGS09	EGS10	EGS11	EGS12	EGS13	EGS14	EGS15	EGS16	EGS17	EGS18	EGS19	EGS20	EGS21
EC15	1	0	1	1	1	1	0	0	1	0	1	1	1	1	1	1	1	0	0	1	0
EC16	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	1	0	0	1	0
EC17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
EC18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
EC19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
EC191	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
EC192	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
EC193	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
EC20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
EC201	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Annex 5: Assessment of changes in the ECOSYSTEM: a necessary step towards

CONTEXT

1. Assessment of changes in the ecosystem : a necessary step towards

assessment of GES

2. Flux of information : ODEMM formalizm

from data listed in 2012 report to end-products

THIS CONTRIBUTION IS ABOUT

1. A statistical alert system for detecting changes in series of indicators and series of maps: Decision-Cusum control charts

2. Traffic light approach to summarize information on significant changes:

- Summary table in all compartments

a) Detection of changes in time-series of indicators using CUSUM control charts

Principle of Decision-Cusum:

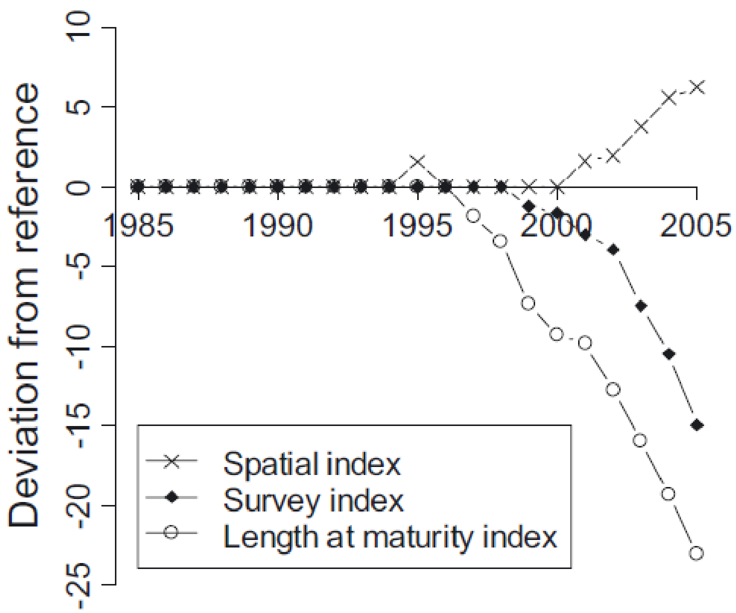
1) Choice of a reference period → mean, variance, autocorrelation, distribution

2) Choice of risks α and β for detecting changes in the mean → statistical tuning of the power of change detection

3) Statistical detection of change in the mean at time t with defined risks in comparison to the reference period

b) Example of a CUSUM summary table to monitor changes in stock status using indicators

Example of the evolution of North Sea cod using CUSUM on different indicators

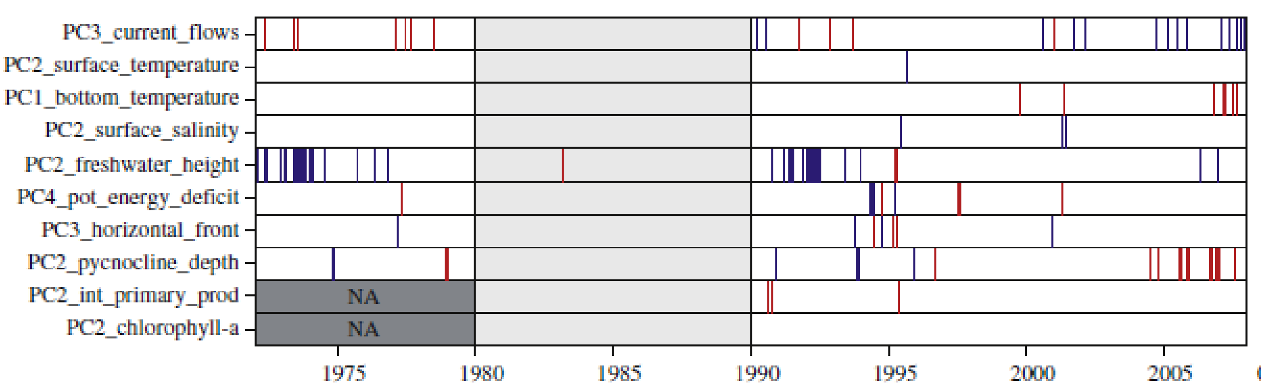


Detection of changes in series of maps using CUSUM and EOF Principle :

1) Perform EOF decomposition on a series of maps: invariant patterns in space (eigen-vectors of the maps), their associated amplitudes in time (principle components)

2) Apply CUSUM on the time-series of principle components (PCs are « indicators »)

3) Summarize results in a traffic light table



Evolution of the French shelf maps as derived from a hindcast of Ifremer's PBGC model MARS: red above, blue below reference mean

Conclusions

1. METHOD

Statistical detection of changes with defined risks in time-series of indicators and/or patterns in maps

Applicable to data, model outputs, satellite image

Capacity to create tables/graphs of statistically significant changes in all compartments of the ecosystem

2. WGEAWESS

Need to chose data to assemble in different components of the ecosystem (+pressures): scoping at the 2013 meeting + intersessional work

Need to implement procedures to analyse changes in these data : workshop at the 2014 meeting?

Sources:

UE Project FISBOAT : Use of indicators derived from survey data to monitor changes in the status of fish stocks. Outcomes published in a special issue : Aquatic Living Resources, 22(2), 2009

Progress in Oceanography 87 (2010): 83-93. Statistical monitoring of spatial patterns of environmental indices for integrated ecosystem assessment

Annex 6: ICES Bay of Biscay and Atlantic Iberian waters Ecosystem Overview

Preamble

This document represents the development of the ICES ecosystem overview of the Bay of Biscay and Atlantic Iberian waters ecoregion. It is one of a set of overviews being produced by ICES to cover all ecoregions within the ICES area.

The overviews are to become a central component of the ICES advice and exist for four purposes:

1) to describe the location, scale, management and assessment boundaries of the ecoregion

2) to alert ICES expert groups to situations within the environment and ecosystems that are expected to significantly influence their advice

3) to describe the distribution of human activity and resultant pressure (in space and time) on the environment and ecosystem

4) to describe the state of the ecosystem (in space and time) and to comment on pressures accounting for changes in state

This current document should be seen as a 'work in progress'. The completed overviews should be seen as living documents.

The intended audiences for the ecosystem overviews will include regional commissions and the ICES community and networks. Owing to the range of audiences, the overviews will be evolving documents, driven by top down processes (advisory requests and ICES decisions about strategic direction) and bottom up processes (information streams high-lighting 'new' issues from the ICES community and network). The overviews will highlight the capacity of ICES to provide integrated advice that will be required to meet the future needs of the recipients of ICES advice.

1 Description of the Ecoregion

1.1 Ecoregion boundaries and geography

The Bay of Biscay and Atlantic Iberian (BoB-Iberia) waters ecoregion has been recently delineated in a number of ways (Figure 1). The ICES ecoregion, the ICES fishing area, the OSPAR region III and the new MSFD ecoregion all differ slightly. The distinguishing differences are found at the boundaries. Iberian Seas 1.2 map.pdf

For the purpose of the overview of the Bay of Biscay and Atlantic Iberian Waters (BoB-Iberian) will be considered to consist of four subregions:

1) The Bay of Biscay Shelf
2) Northern Iberian Shelf (NIS)-43º 30′N from Cape Ortegal (ca. 8°W) to the mouth of the river Bidasoa (ca. 2°W);
3) Western Iberian Shelf - Cape Estaca (43°48′N, 7°41′W) to Cape Santa Maria (36º 57′N, 7º 53′ W).
4) Gulf of Cadiz- Cape Santa Maria (36º 57′N, 7º 53′ W) to

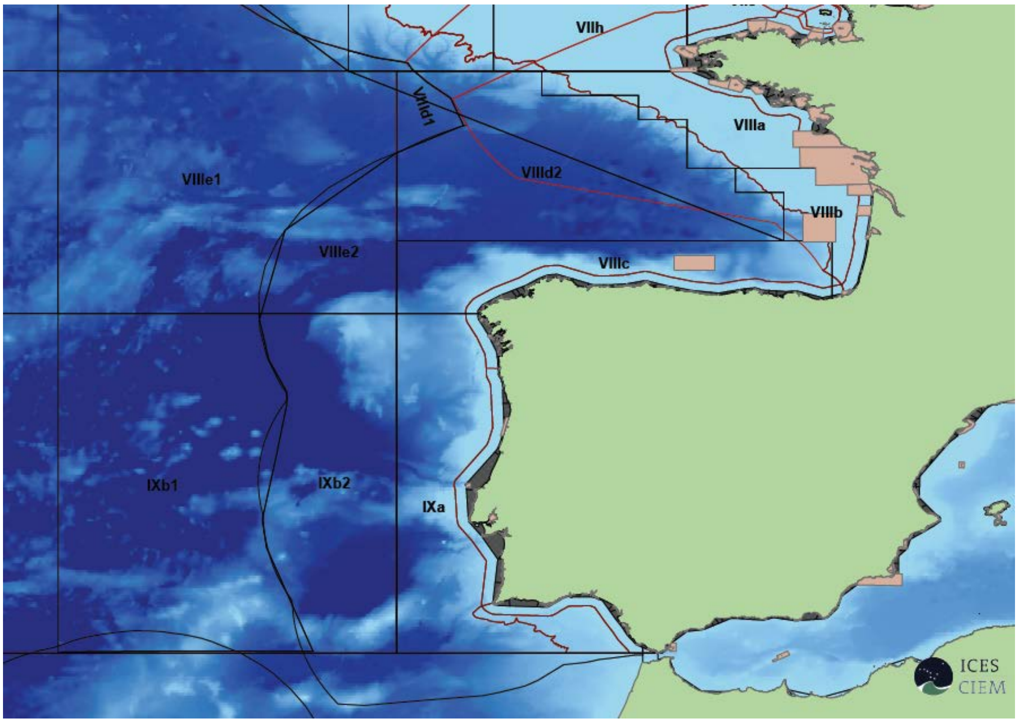


Figure 1.1. Bay of Biscay and Atlantic Iberian waters ecoregion showing National EEZ, MSFD, ICES areas, Natura 2000.

1.2 Ecoregion management

This ecoregion falls within th EEZs of France, Spain, and Portugal. This also means that the European Union has the competence for its management. The area falls into the competency of OSPAR (OSPAR Region IV). In EU waters the management of fisheries has a regional consultative body the Southern Regional Consultative Council (RAC).

Maps show the delineation of closed areas (Natura 2000, fisheries closures, gear restrictions).

2 Ecoregion Key Signals

2.1 Physical and chemical oceanography

This ecoregion extends from west of Brittany (48°N) to the Strait of Gibraltar (36°N). A large shelf extends west of France. The southern part of the Bay of Biscay along the northern Spanish coast is known as the Cantabrian Sea and is characterized by a narrow shelf. Further south a narrow shelf continues west off Portugal (Figure 7.1.1). Lastly, to the south, the Gulf of Cadiz has a wider shelf strongly influenced by the Mediterranean Sea. Within these zones the topographic diversity and the wide range of substrata result in many different types of coastal habitat (OSPAR, 2000).

Most of the water masses are of North Atlantic origin, including those that have been transformed after mixing with the Mediterranean water. The region is affected by both the subpolar and subtropical gyres depending on latitude, but the general circulation in the area mainly follows the subtropical anticyclonic gyre in a relatively weak manner (1-2 $cm.s^{-1}$). Figure 1 indicates the principal water masses and currents as explained by Mason et al. (2006).

In northeast Bay of Biscay, mainly in summer, upwelling events occur off southern Brittany and the Landes coastline and may induce low-salinity lenses detached from the river plumes (Koutsikopoulos and Le Cann, 1996; Puillat *et al*., 2006; Lavín *et al*., 2006). In Portugal, west of Galicia and in a narrow coastal band in the western Cantabrian Sea, upwelling events are a common feature, especially in summer (Fraga, 1981; Fiuza *et al.*, 1982; Blanton *et al.*, 1984; Botas *et al.*, 1990; OSPAR, 2000).

Water temperature is highest to the south, where it is influenced by the Mediterranean Waters. For example, the yearly mean temperature at 100m depth is 11.2°C to the north of the advisory region, 48°N, and 15.6°C to the south, 36°N (Levitus, 2001).

To consider for the purpose of the overview the following products are required:

1) Bay of Biscay Shelf – not presented this year (see report 2011)

2) Northern Iberian Shelf – section 3

3) Western Iberian Shelf – section 4

4) Gulf of Cadiz – section 5

Metric	Temporal measure	Definition of space	product delivered by
Temperature (SST)	Mean monthly , integrated over water column	1, 2, 3, 4	WGOOFE & WGOH
Stratification	Timing & area by year	1	WGOOFE
Nutrients (dissolved nitrogen and phosphorus)	Winter seasonal concentrations	1, 2, 3, 4	???
Bottom oxygen depletions	Events and area	2, 3	WGOOFE
Salinity events	Events and area	2, 3	WGOOFE
Estimates of flux	Trends in fluxes	1, 4	WGOOFE & WGOH
Global climatic indices	Hurrell winter NAO index. East Atlantic pattern		WGOH
Upwelling indices	Winter and Summer trends	1,2,3,4	WGOOFE
River fluxes	Trends fluxes	1,2,3,4	????

2.2 Global climatic indices relevant to the ecoregion

The North Atlantic Oscillation (NAO) seasonal interplay between the Azores high pressure cell, which is strong and displaced northwards during summer, and the Icelandic low, which weakens then, governs the setup of favourable upwelling winds (northelies) off western Iberian between April and October (Wooster et al., 1976; Fiúza et al., 1982). During Winter the dominante wind direction changes, and poleward current becomes a feature at all levels between the surface and the Mediterranean water (MW) at ~ 1500 m along the Iberian shelf edge and slope. The surface poleward current carries relatively warm, saline water identifiable in SST satellite imagery (Frouin et al., 1990; Relvas et al., 1990; Peliz et al., 2005) that propagates to locations as far as the Cantabrian Sea (Pingree and Le Can, 1990) and Goban Spur, northwest of the UK at the continental margin (Pingree, 1993). Eastern Atlantic pattern has a similar structure to NAO in winter and consists of a north–south dipole of anomaly centers which spans the entire North Atlantic from east to west. The main cell is located westward from the British Islands and the band of high values extends to lower latitudes, over northern Africa and southern Europe. This subtropical link also makes the pattern distinct from its NAO counterpart. The positive phase of the EA pattern is associated with above-average surface temperatures in Europe in all months.

The impact of climate variability on the marine ecosystems and evidence of regime shifts in the Iberian Waters have been recently reported by Borges (2013).

Figures 2.1 and 2.2 below represent available time-series of global climatic indices, Winter NAO and EA, known to impact the ecoregion system productivity at a variety of time-scales.

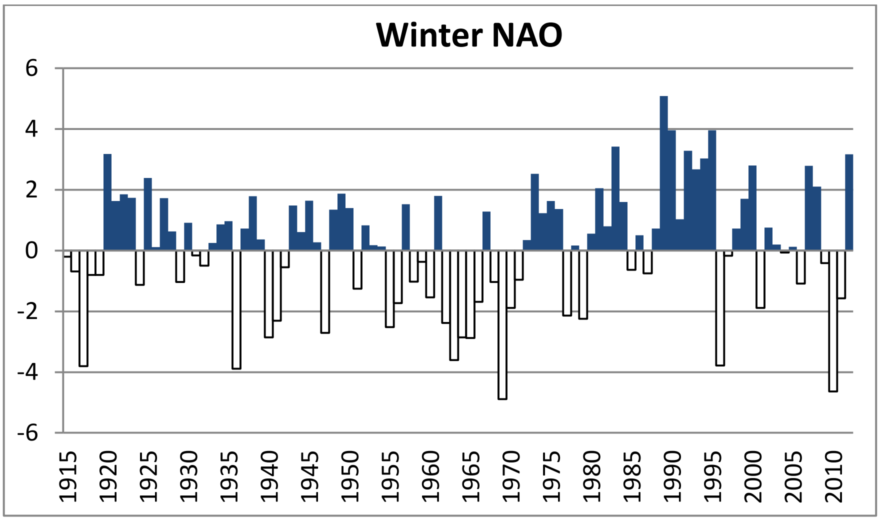


Figure 2 1. Station-based extended winter NAO index (December_March) (http://climatedataguide.ucar.edu/guidance/hurrell-north-atlantic-oscillation-nao-index-station-based).

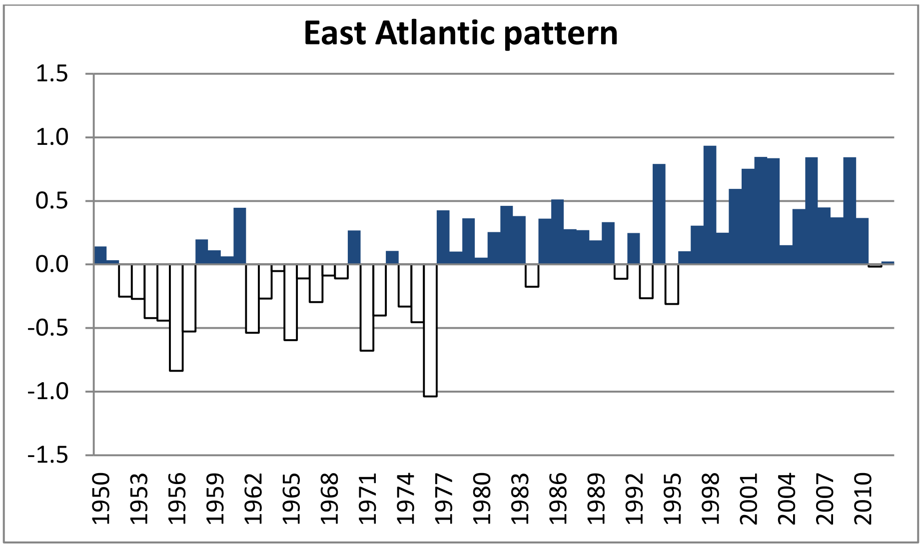


Figure 2.2. East Atlantic pattern teleconnection index (http://www.cpc.ncep.noaa.gov/data/teledoc/ea.shtml).

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3 Northern Iberia Shelf subregion

3.1 Subregion Description

The Northern Iberian Shelf (NIS) subregion comprises the Cantabrian Sea (Figure 3.1.2.1). The coastline runs in the zonal direction at approximately 43º 30'N from Cape Ortegal (ca. 8°W) to the mouth of the river Bidasoa (ca. 2°W). Rocky shores represent around 90% of the coastal margin, predominating over a multitude of small sandy beaches with maximum lengths up to 4 km, and several small-sized shallow estuaries. Inland, the Cantabrian mountain range runs parallel and close to the coastline, and consequently, numerous short water courses (i.e. streams and small rivers with an annual average flow between 1-10 and 10-100 $m^3 \cdot s^{-1}$ respectively) drain along the coast. The Nalón river is the largest, with an annual average flow of 109.0 m^3 s^{-1} corresponding to a basin surface of 4866 km^2 (Prego and Vergara, 1989).

The continental shelf is narrow (width ranging between 30-40 km on the West and 10-15 km on the East) and indented by several canyons. The continental slope is relatively steep with a slope around 10%. Two large physiographic features (i.e. marine landscapes) stand out on the shelf: the Avilés canyon system to the West of Cape Peñas (ca. 6°W) and Cachucho (or Le Danois) Bank, a plain with depths ranging between 450 and 600 m located at approximately 15 km (ca. 44°N) North of the continental shelf at 5º W that has been recently included in the OSPAR Network of Marine Protected Areas. The western corner of this area, which contains the geographical limit between the Iberian Peninsula and France at land, is also crossed by another important marine canyon: the Cap Breton Canyon. It is a submarine valley classified as a ''gouf'' which begins less than 400 m from the shoreline (in front of the Adour river mouth) and extends from east to west parallel with the Spanish coast for over 250 km, affecting clearly the dynamics of the surrounding marine system. The canyon is subjected to the combination of river plumes and ocean currents i.e. local upwellings and poleward coastal currents along Basque and North Aquitaine coast (Ferrer et al., 2009; Rubio et al., 2013). And it also contains an area which is restricted to the fishing activity ((Delayat and Legrand, 2011; Sanchez et al., 2013)).

Figure 3.1.2.1. Map of the North Iberian Shelf (NIS) subregion, limited by cape Ortegal to the west and the mouth of the river Bidasoa to the east. The three outstanding physiographic features of the area are shown: the Avilés canyon, the Cachucho bank and the Cap Breton canyon.

The climate is oceanic (Cfb in the Köppen climate classification system).Monthly average temperatures range 10 ºC between summer maxima (ca. 20 ºC) and winter minima (ca.10 ºC) (Figure 3.1.2.2a). The mean of the total annual precipitation ranges between ca. 800 and 1000 mm·year^{-1} in the western and easternmost part of the subregion. Precipitation is distributed during the whole year although with a summer minimum (Figure 3.1.2.2a). Winds tend to blow alongshore, predominantly from the west in winter and from the east in summer (Figure 3.1.2.2b) (Rubio et al., 2013; Ruíz-Villareal et al., 2012);). The height and proximity of the Cantabrian range to the coast contribute to increased rainfall when westerly winds cause the adiabatic cooling of humid oceanic air

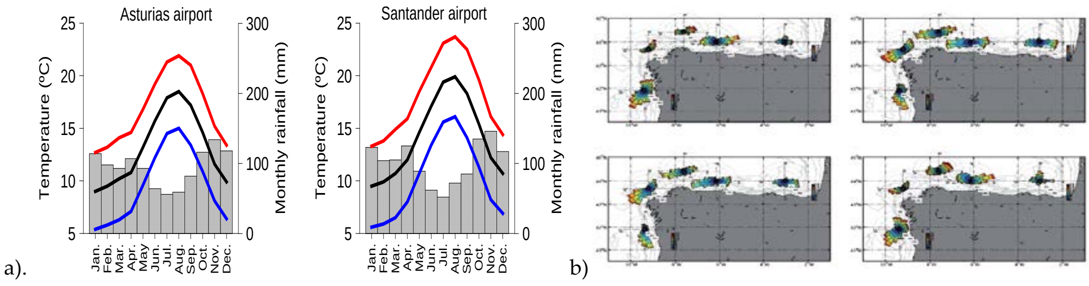


Figure 3.1.2.2. (a) Average monthly mean temperature (black line), average monthly mean of daily maxima (red line), average monthly mean of daily minima (blue line) and average monthly rainfall (grey bars) from 1971 to 2000 at the meteorological stations of Asturias and Santander airports (see locations in Figure 3.1.2.1). Data source: Agencia Estatal de Meteorología, Government of Spain (http://www.aemet.es). (b) Wind patterns during winter, spring, summer and autumn (clockwise) recorded in the array of buoys of Puertos el Estado (http://www.puertos.es) and the buoy Augusto Linares from the Instituto Español de Oceanografía (http://www.boya_AGL.st.ieo.es).

The atmospheric teleconnection patterns affecting the NIS subregion show marked year-to-year variation (Figure 3.1.2.3), and are correlated with precipitation and temperature at the scale of the whole Bay of Biscay and Atlantic Iberian ecoregion (Figure 3.1.2.4). The main modes are the NAO and EA, which show significant increasing trends (Table 3.1.2.1a).The AMO is in a positive phase since 1995 (Figure 3.1.2.3; Table 3.1.2.1a)(Ruíz-Villareal et al., 2012).

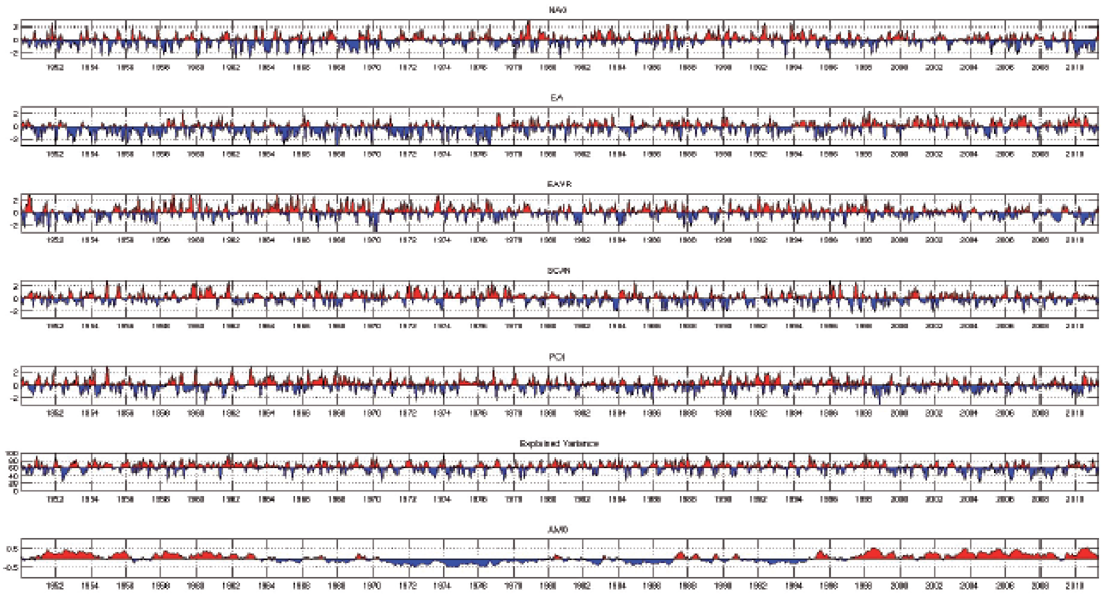


Figure 3.1.2.3. Time-series (1947-2011) of the main climatic modes (NAO, EA, EA/WR, SCAN and POL –North Atlantic Oscillation, Eastern Atlantic, Eastern Atlantic / Western Russia, Scandinavian and Polar indices respectively), the variance explained by all modes and the Atlantic Multidecadal Oscillation index (AMO)

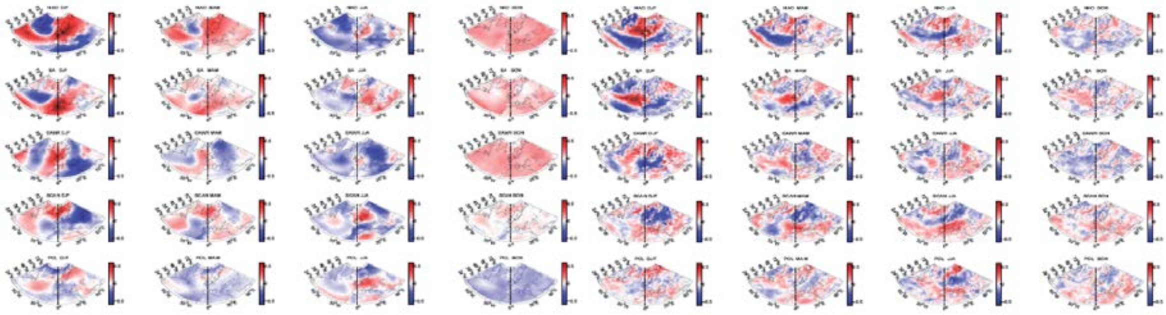
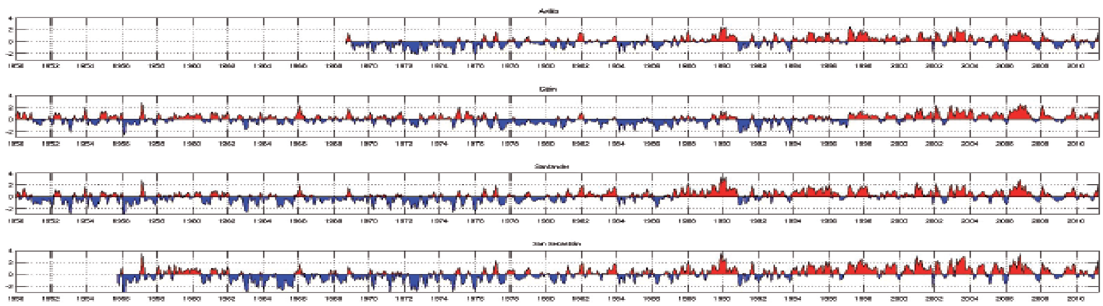
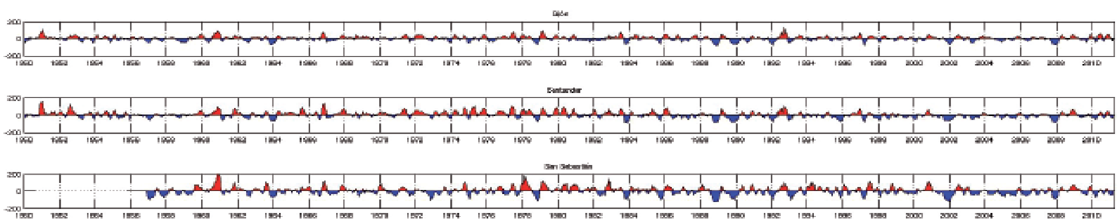


Figure 3.1.2.4. Spatial correlation (by seasons from left to right: winter –DJF, spring –MAM, summer –JJA, and autumn –SON) between atmospheric teleconnection patterns (from top to bottom: NAO, EA, EA/WR, SCAN and POL) and air temperature (left panel) and precipitation (right panel).

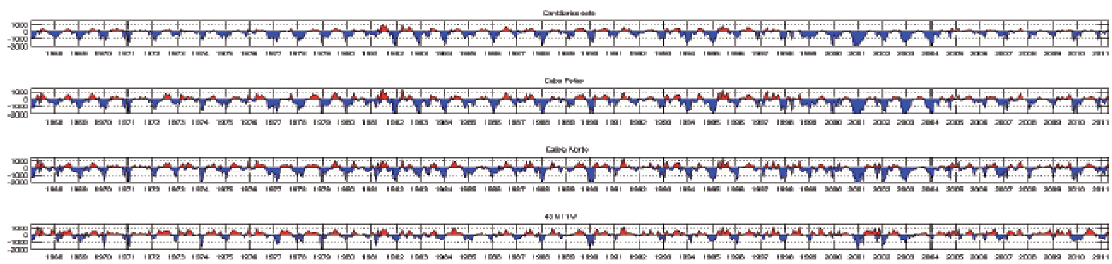
Air temperature shows a statistically significant trend in the northern part of the Western Iberian Shelf (WIS) subregion but not in the NIS (Table 3.1.2.1b). Temperature anomalies, however, were mostly positive since the mid 1990s in several locations along the Cantabrian coast (Figure 3.1.2.5a).



(a)



(b)



(c)

Figure 3.1.2.5. Time-series of meteorological and hydrographic variables at different locations of the NIS subregion. (a) Air temperature anomalies (°C) in the meteorological stations of Avilés, Gijón, Santander and San Sebastian for the period 1950-2011 (http://www.aemet.es); (b) Accumulated precipitation anomalies (mm/month) in the meteorological stations of Gijón, Santander and San Sebastian for the period 1950-2011 (http://www.aemet.es); (c) Upwelling index for the period 1967-2011 in east, central and western Cantabrian sea.

Precipitation does not show a significant long-term trend (Table 3.1.2.1b), although cumulate precipitation anomalies were predominantly negative in the last two decades in several locations along the Cantabrian coast (Figure 3.1.2.5b). The upwelling index at 43°N, 11°W, considered a reference point for the northern part of the WIS subregion, shows a significant decreasing trend (Table 3.1.2.1b). No significant trends were registered however at different locations along the NIS subregion. Note that in the WIS subregion, upwelling is associated with northerly winds while in the NIS subregion it is promoted by easterlies. In the NIS subregion, strong downwelling favourable westerlies were recorded in the late 1990s early 2000s (Figure 3.1.2.5c).

(a)

NAO	0.028	0.0062	0.7
EA	0.137	0.0189	6.6
EA/ WR	0.009	–	–
SCAN	−0.027	−0.0101	1.9
POL	0.006	–	–
AMO	−0.032	0.0062	16.4

(c)

Vigo	13.63	0.03	1.0
Coruña	14.40	0.04	2.3
Avilés	13.26	0.04	1.6
Gijón	14.04	–	–
Santander	14.45	0.03	1.5
San Sebastián	14.34	0.04	1.8

(b)

AFLO	−8.662	−4.0704	0.8
TAG	15.422	0.0243	2.1
TSG	15.632	0.0195	2.0
UG	0.736	–	–
VG	−2.016	–	–
TAC	15.090	–	–
TSC	15.507	–	–
UC	1.447	–	–
VC	−0.598	–	–

(d)

Vigo	158.8	–	–
Coruña	84.4	–	–
Avilés	91.5	−0.61	1.4
Gijón	79.3	–	–
Santander	99.2	−0.72	2.1
San Sebastián	142.1	–	–

Table 3.1.2.1. Average, rate of annual change (linear trend; units/year) and percentage of total variance of the time-series explained by the linear trend component, if statistically significant, for different meteorological and climatic variables. (a) Teleconnection patterns (NAO, EA, EA/WR, SCAN, POL and AMO); (b) Meteorological and hydrographic variables: AFLO, upwelling index at 43°N, 11°W; TAG and TSG, air and sea surface temperature in Galicia (northern WIS); UG and VG, zonal and meridional wind components in Galicia; TAC and TSC: air and sea surface temperature in the Cantabrian (NIS); UC and VC: zonal and meridional wind components in the Cantabrian; (c) Air temperature (°C) and (d) precipitation (mm/month) at different locations along the northern WIS and NIS subregions.

Key physical and chemical signals

The whole NIS subregion shows a positive linear trend of sea surface temperature (SST), which is on average of ca. 0.02-0.03 °C per decade. The rate of SST increase is more acute during the spring-summer (González-Pola et al., 2012; González-Pola and Izquierdo, 2012, Michel et al., 2009).

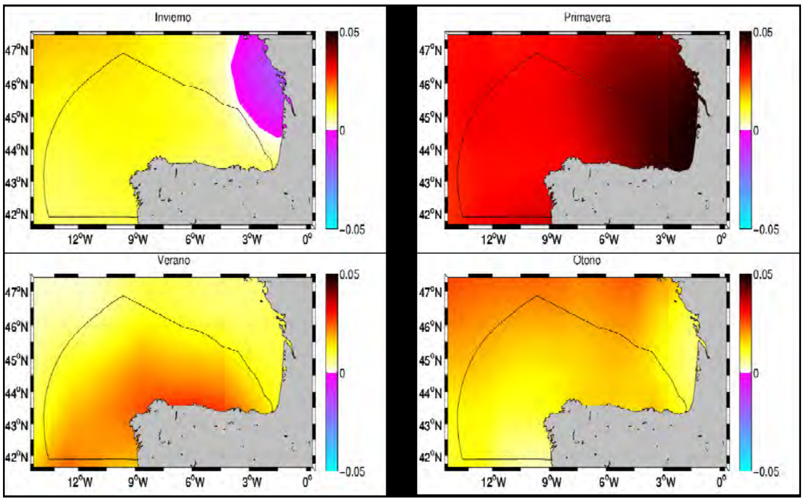


Figure 3.1.2.3. Linear trend of sea surface temperature (SST) in the NIS subregion. The re-analysis of SST values is based on weekly data on a 1° by 1° grid from the early 80's (Reynolds et al., 2002).

Temperature and salinity at the subsurface and bottom layers of the water column show also a positive trend. This trend in the thermohaline properties at the level of the permanent thermocline has been observed almost worldwide (Solomon et al., 2007), but has been more acute in the last decades in the North Atlantic (Holliday et al., 2008). Figure 3.1.2.4 illustrates the changes of thermohaline properties in the last two decades in the central part of the NIS subregion at different levels of the water column (González-Pola et al., 2012).

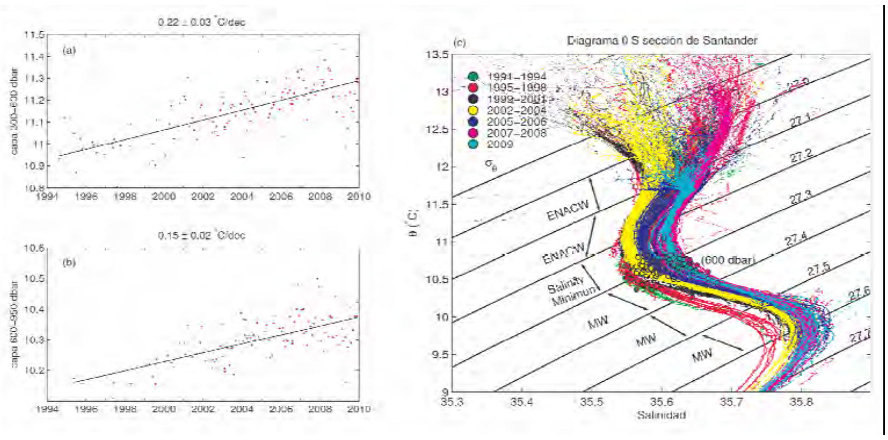


Figure 3.1.2.4. (a) Evolution of temperature in the central part of the NIS subregion (off Santander, Figure 2.1.2.1) in the water layers representative of central waters (300-600 dbar) and (b) in the upper part of the Mediterranean waters (600-950 dbar). (c) Changes in the Θ-S diagram between 1991 and 2009.

Sea level shows a significant long-term increasing trend in the northern part of the WIS and in the NIS. The rates of change are around 2.5 mm/year (2.37, 2.44 and 2.65 mm/year in Vigo, A Coruña and Santander respectively) (Figure 3.1.2.5) (García et al., 2012), slightly higher than the estimated global trend of sea level rise (1.8 mm/year in the last 70 years; IPCC 2007).

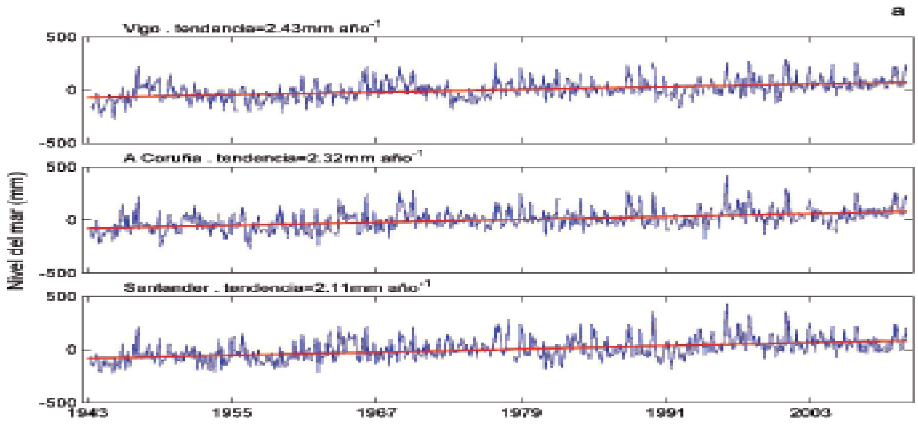


Figure 3.1.2.5. Time-series of monthly means of sea level (mm) and long-term linear trends (mm/year) in different locations of the northern part of the WIS (Vigo and A Coruña) and NIS (Santander) subregions.

In terms of productivity (using satellite-derived surface chlorophyll as subrogate variable), the subregion can be divided in different zones (Figure 3.1.2.6a-b): oceanic ('NorO1'), shelf ('Plataforma') and coastal waters ('NorC1', 'NorC2' and 'NorC3'). Surface chlorophyll shows a conspicuous seasonality in each of these zones (Figure 2.1.2.6c) (Cortés et al., 2012). Satellite-derived chlorophyll (SeaWiFS, 1998-2007) does not show significant long-term trends in the northern part of the WIS and in the NIS subregions (Bode et al., 2011).

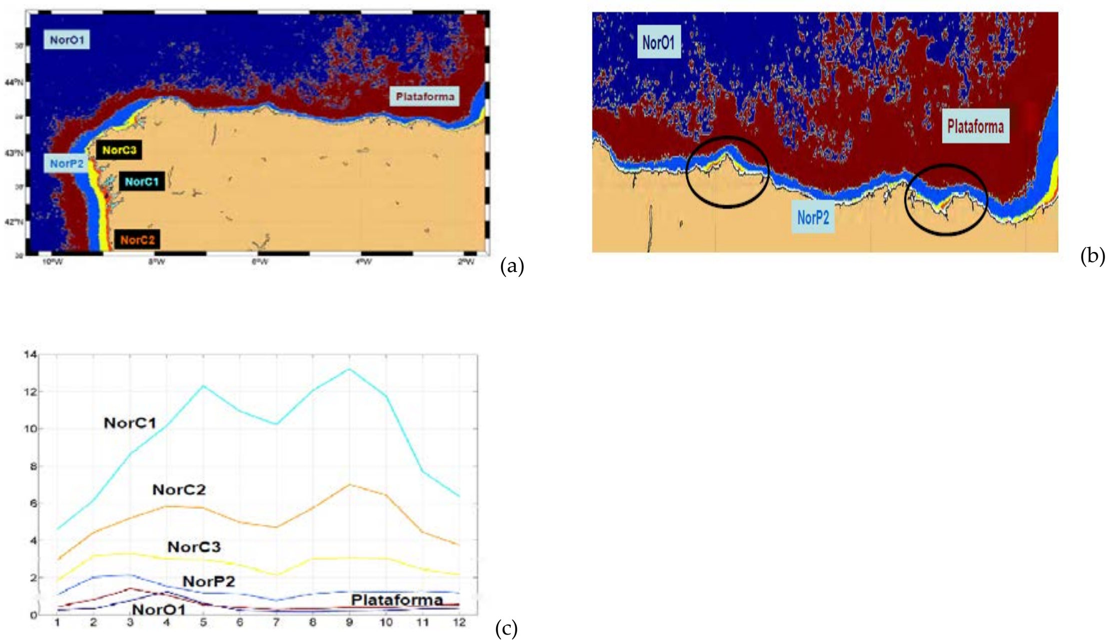


Figure 3.1.2.6. Zones of productivity obtained from the analysis of satellite derived surface chlorophyll (MODIS-Aqua, 07/2002 to 12/ 2012; http://www.oceancolor.gsfc.nasa.gov/) (a) The North Iberian Shelf and the northern part of the Western Iberian Shelf subregions; (b) Detail for the NIS subregion; (c) Seasonal variation in each of the productivity zone

Nutrients and chlorophyll in the water column show a marked seasonality. The seasonal pattern differs along the shelf, presenting contrasting features between the Western Iberian and the

North Iberia shelves (WIS and NIS subregions) which are related to the differential influence of coastal upwelling (promoted by northerlies and easterlies respectively in each subregion) (Figure 3.1.2.7.) (Nogueira et al.,2012).

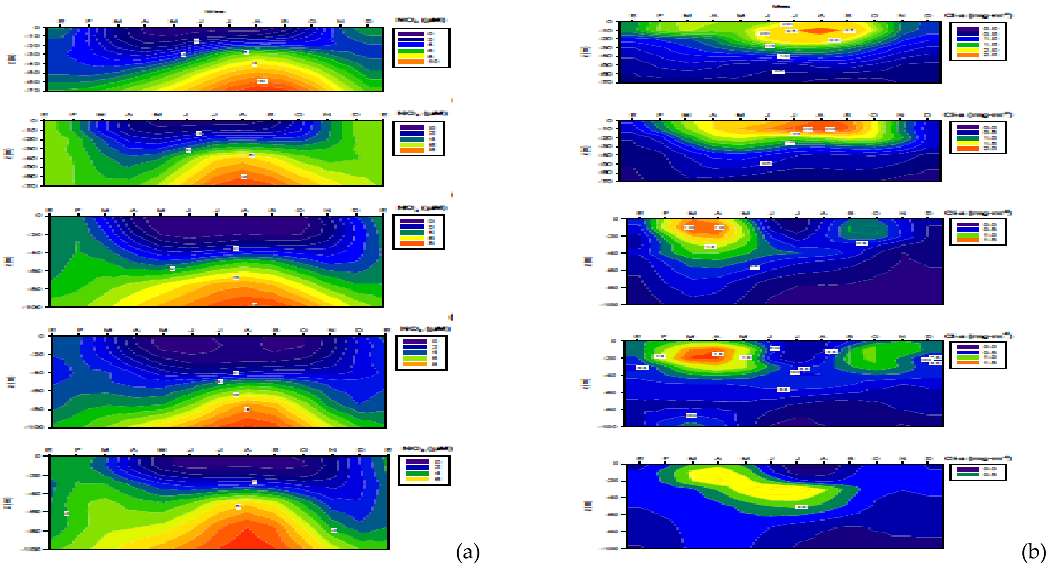


Figure 3.1.2.7. Seasonal variation of nitrate (a) and chlorophyll (b) in the mid part of the shelf off (from top to bottom): Vigo, A Coruña (which belong to the northern part of the Western Iberian Shelf subregion –WIS), Cudillero, Gijón and Santander (which belong to the North Iberian Shelf subregion –NIS). Note that the range of values depicted is different for each plot.

The year-to-year variability of nutrients in different productivity zones of the NIS subregion is a relevant temporal component. The long-term changes derived from the analysis of data all along the subregion (Figure 3.1.2.8a) show a significant increment from 2005 (Figure 3.1.2.8b-c), although the concentration is within climatological, reference values (i.e. good environmental status, GES).

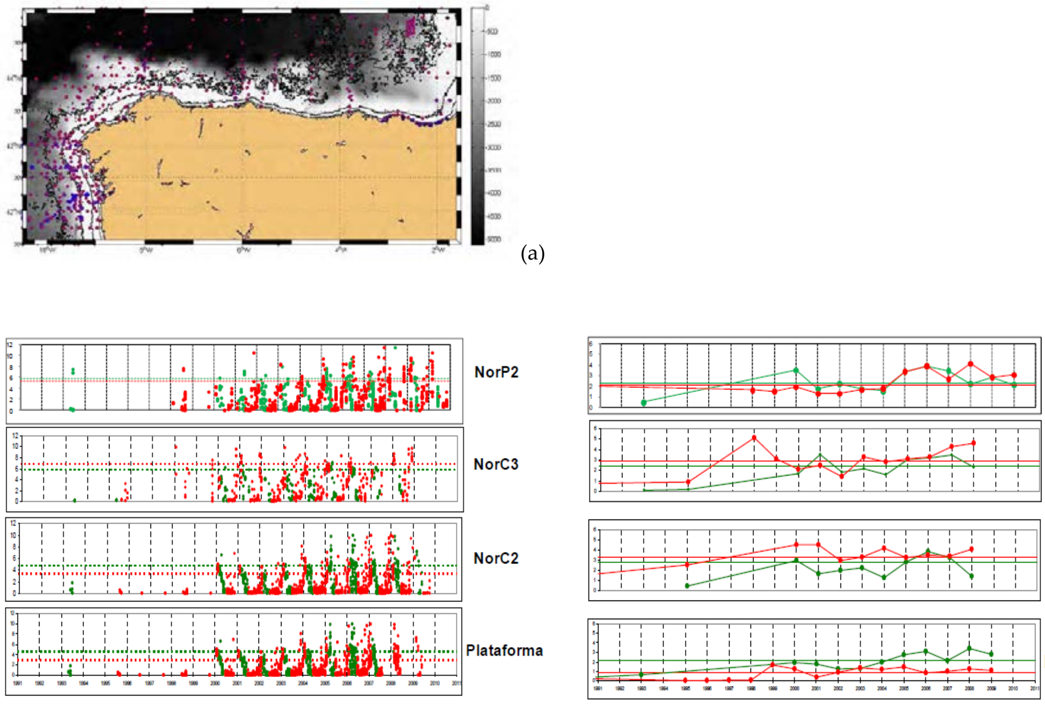


Figure 3.1.2.7. Concentration of inorganic nutrients. (a) Position of the sampling stations; Monthly (b) and annual (c) variability of nitrate in contrasting zones (Figure 3.1.2.6) (in b, the discontinuous horizontal lines mark the 90th percentile; in c, the continuous horizontal lines define the climatological average) during periods of high (green) and low (red) productivity.

3.2 Biotic processes

Ecotype: Bacterioplankton and phytoplankton

Abundance/biomass of autotrophic picoplankton in the mid-shelf of the central part of the NIS subregion shows a marked seasonality but not a significant long-term trend (Figure 3.2.2.1a) (Morán et al., 2012). On the contrary, heterotrophic picoplankton does not present a neat seasonality but a significant long-term increasing trend (Figure 3.2.2.1b), which several authors have associated to the sea surface warming trend (Morán et al., 2010).

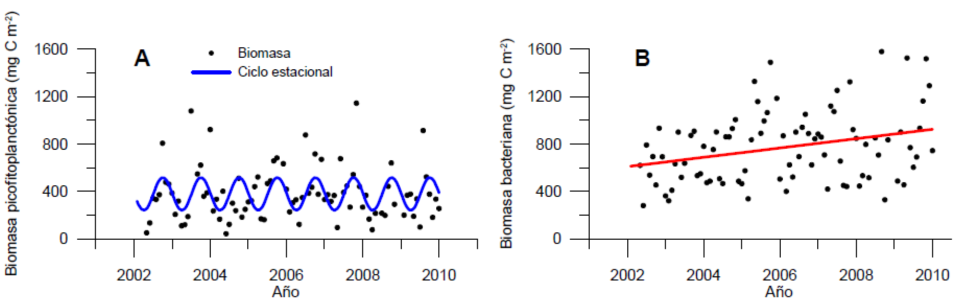


Figure 3.2.2.1. Time-series of monthly, water column integrated (0-75 m) values of biomass (mgC/m²) of autotrophic (a) and heterotrophic picoplankton (b) in the mid-shelf off Gijón (central part of the NIS subregion). The continuous lines show the statistically significant components of variation of the time-series: the seasonal and the long-term trend in (a) and (b) respectively.

Water-column integrated chlorophyll (SeaWiFS, 1998-2007) does not show significant long-term trends in the northern WIS and NIS subregions (Figure 3.2.2.2) (Bode et al., 2011). Primary production (14C incubation method, 1993-2008) shows a positive linear trend in the northern WIS subregion (inner shelf off A Coruña) but not in the central part of the NIS subregion (mid-shelf near Avilés canyon) (Figure 3.2.2.2) (Bode et al., 2011; Bode et al., 2012a).

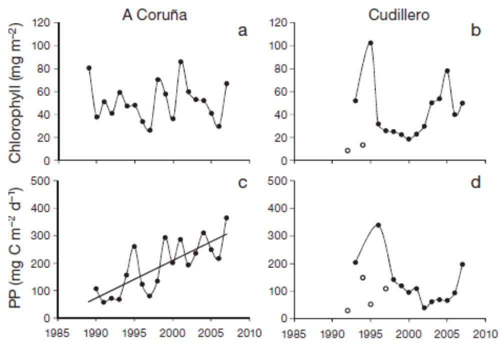
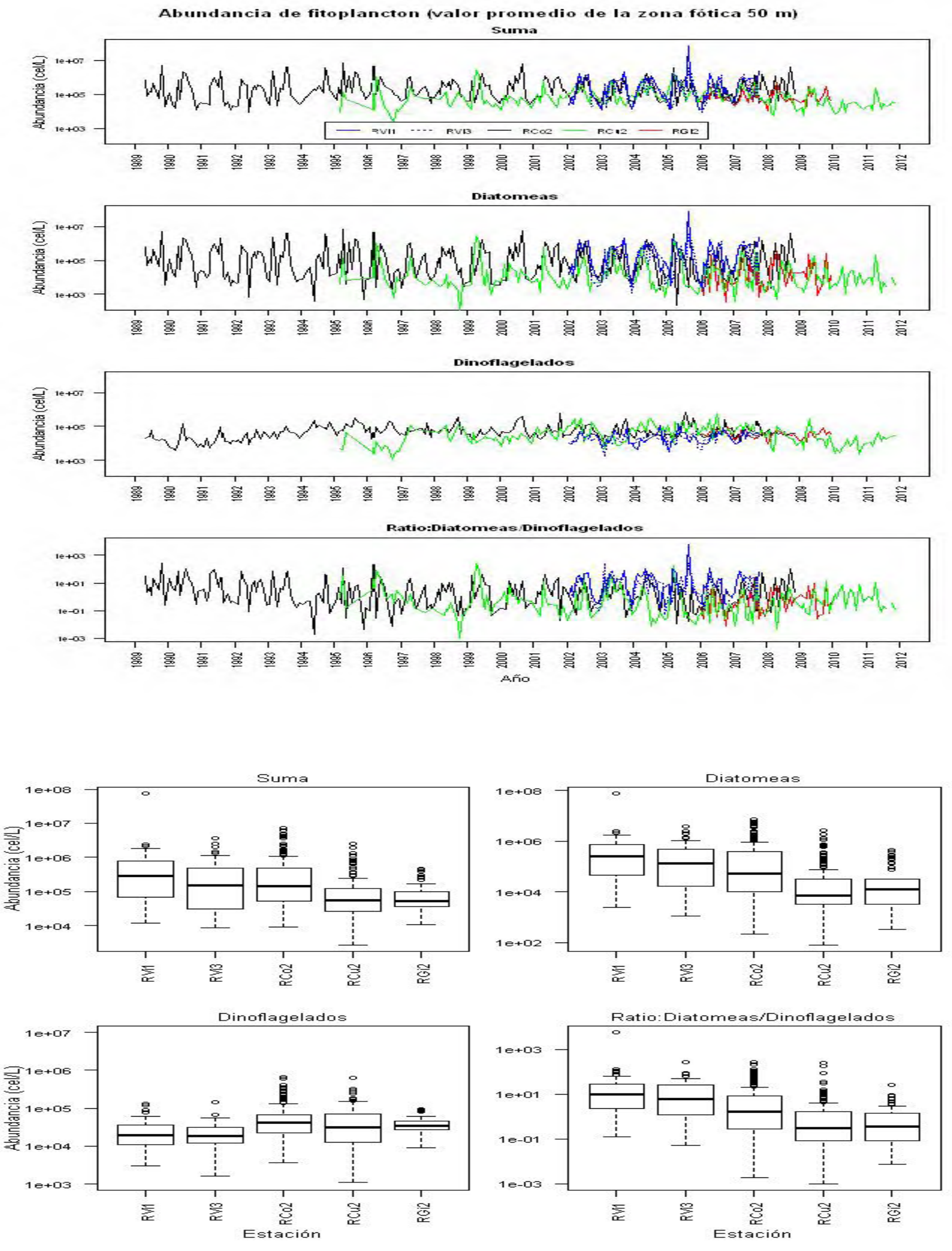


Figure 3.2.2.2. Time-series of annual mean values of water column integrated chlorophyll (mg/m^3; top) and primary production (mgC/m^2/day; bottom) in the northern part of the WIS (A Coruña, left) and in the central part of the NIS (Cudillero, right).

The abundance/biomass of phytoplankton does not show significant long-term changes (Figure 3.2.2.3a). Climatological (reference) values (Figure 3.2.2.3b) differ however across-shelf, decreasing from coastal to oceanic areas, and alongshelf, characterized by a relative predominance of diatoms vs. dinoflagellates in the northern Western Iberian (WIS) compared to the North Iberian (NIS) subregions (Velasco et al., 2012; Varela et al., 2012).



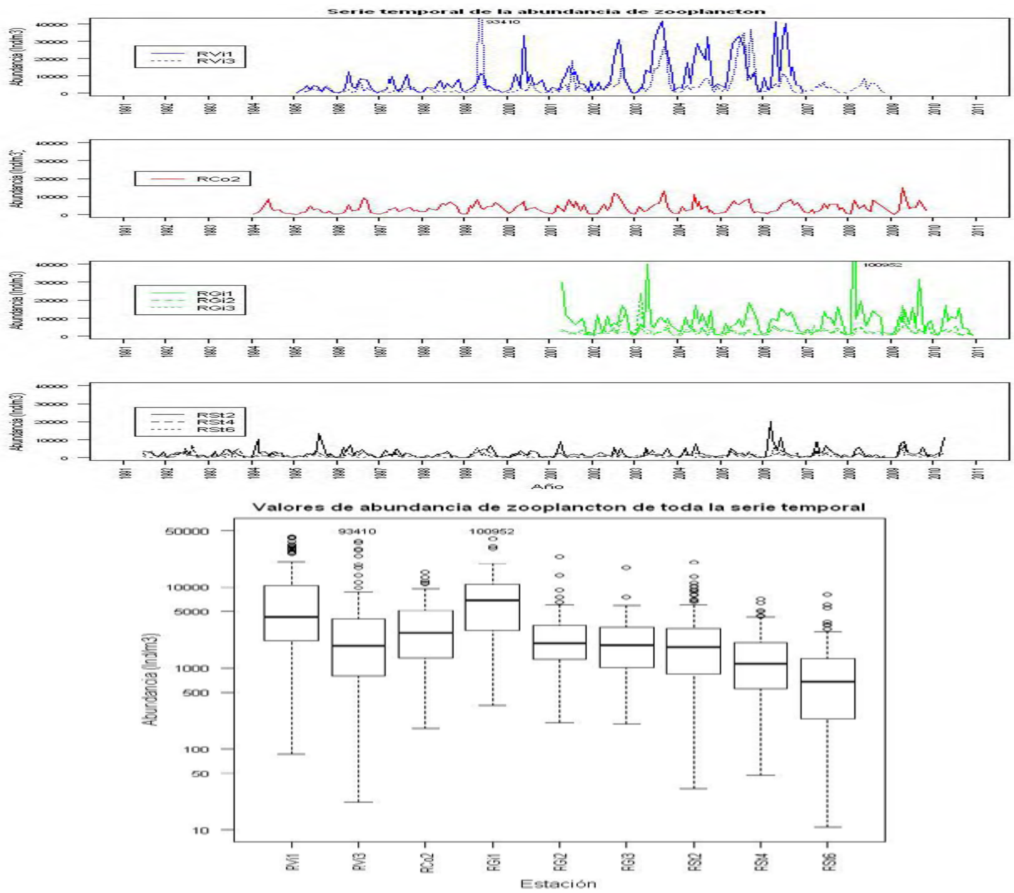
(a)

(b)

Figure 3.2.2.3. (a) Time-series of abundance of phytoplankton taxa (cells/L) (diatoms plus dinoflagellates; diatoms; dinoflagellates; ratio between diatoms and dinoflagellates) in the euphotic layer (upper 50 m of the water column) along the mid-shelf of the northern Western Iberian Shelf (off Vigo –RVi1 and RVi3, and A Coruña –RCo2) and North Iberian Shelf (off Cudillero –Rcu2, and Gijón –Rgi2) subregions. (b) Climatological values (average, upper and lower quartiles and upper and lower deciles) of phytoplankton abundance taxa.

Ecotype: Zooplankton

The abundance/biomass of zooplankton (organisms larger than 200 µm ESD) does not show significant long-term changes (Figure 3.2.2.4a). Climatological (reference) values (Figure 3.2.2.4b), differ however across and alongshelf: decrease from coastal to oceanic areas and are larger in northern Western Iberian (WIS) than in the North Iberian (NIS) subregions (Velasco et al., 2012; Bode et al., 2012b).



(a)

(b)

Figure 3.2.2.4. (a) Abundance of zooplankton (individuals/m³) at different locations of the northern part of the Western Iberian Shelf subregion (WIS; off Vigo: RVi1 and RVi3 –coastal and mid-shelf stations respectively; and off A Coruña: RCo2 –mid-shelf) and in the North Iberian Shelf subregion (NIS; off Gijón: RGi1, RGi2 and RGi3 –coastal, mid-and outer shelf; off Santander –RSt2, RSt4 and RSt6 –coastal, mid-and outer shelf); (b) Climatological values (average, upper and lower quartiles and upper and lower deciles) of zooplankton abundance.

Ecotype: Fish

To characterize the temporal evolution of the ecotype fish in the NIS subregion, a series of species and/or taxa has been selected according to their functional role in the foodweb structure: small pelagic fish, large pelagic fish, demersal and benthic fish.

Small pelagic fish. The main small pelagic fish species in the NIS subregion are sardine (*Sardina pilchardus*) (Figure 3.2.2.5) and mackerel (*Scomber scombrus*) (Figure 3.2.2.6). Anchovy (*Engraulis encrasicolus*) has only a residual presence in the area, although it is an important fishing resource for the local fleet, which catches it in the eastern part of the NIS subregion and over the French shelf (Bay of Biscay Shelf subregion –BBS) (Figure 3.2.2.7). The rest of the small pelagic community is mainly composed by other less abundant species more common to subtropical waters, such as chub mackerel (*S. colias*), Mediterranean horse mackerel (*T. mediterraneus*) and blue jack mackerel (*T. picturatus*).

Sardine landings in ICES area VIIIc (which comprises NIS and part of the northern WIS) has kept relatively low since the late 1990s (Figure 3.2.2.5a), and biomass estimates since 2009 has been the lowest of the assessment series, comparable to the low values estimated in the late 1990s (Figure 3.2.2.5b) (ICES WGHANSA, 2012).

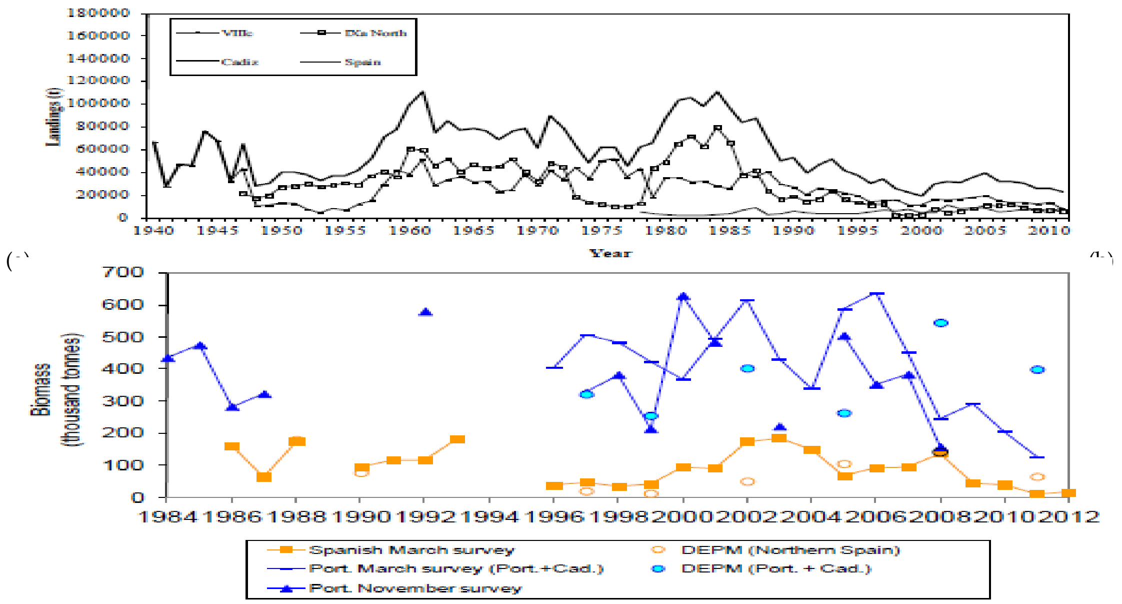


Figure 3.2.2.5. (a) Sardine in ICES areas VIIIc (NIS) and IXa (Bay of Biscay Shelf –BBS subregion). Annual landings by country and by ICES subdivision and country. (b) Total sardine biomass estimated in the different series of acoustic surveys and SSB estimates from the DEPM series covering the northern and southern area of the stock. The Spanish March survey is carried out in the northern part of the WIS and in the whole NIS subregion.

The time-series of the estimated abundance of mackerel (Figure 3.2.2.6a) shows a decreasing trend in the 2+ age-group that could be related with the temporal shift observed in the mackerel availability and in the peak of spawning of this species in Spanish waters (Figure 3.2.2.6b) (Punzón and Villamor, 2009) (ICES WGACEGG, 2012)

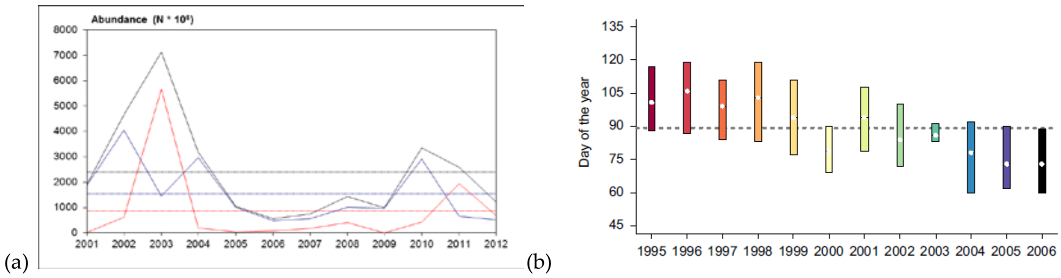
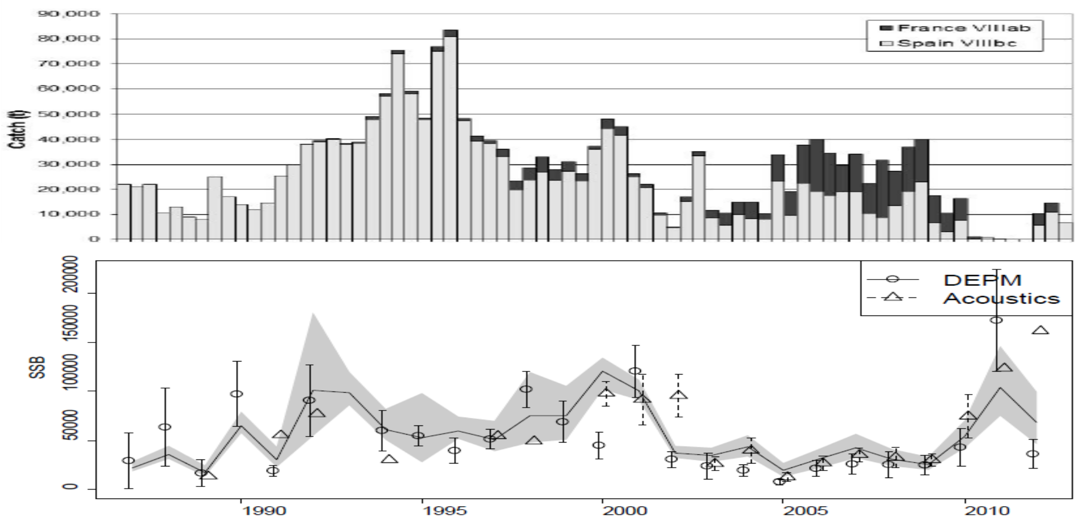


Figure 3.2.2.6. (a) Mackerel abundance (individuals x10⁶): total (black line), age group 1 (red line) and +2 (blue line). The horizontal dotted lines represent the mean number of each of the time-series. (b) Evolution of the day of the year on which 20%, 50% and 80% of the total catch of mackerel (lower end of the box, white dot and upper end of the box respectively) was reached in the period 1995-2006 (the horizontal line marks the mean day of all the years on which 50% of the total catch was reached).

The anchovy fishery recovered slightly from 2010, after a fishing ban that lasted 4 years (2005 and 2009) (Figure 3.2.2.7b). Both DEPM and acoustic biomass estimations indicate that the recovery of biomass took place in 2009-2010 (Figure 3.2.2.7b) (ICES WGHANSA, 2012; ICES WGACEGG, 2012).

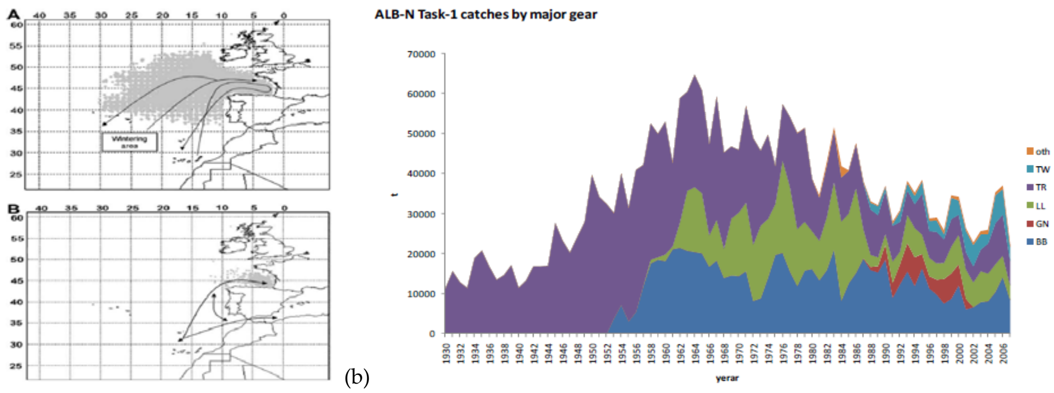


(a)

(b)

Figure 3.2.2.7. Anchovy (a) Historical evolution of catches in division VIII by countries and (b) SSB and 95% probability intervals for the assessment based of DEPM (open circle and solid line) and acoustic surveys (triangle and dashed line).

Large pelagic fish. There are two tuna species, albacore (*Thunnus alalunga*) and bluefin (*Thunnus thynnus*), which are present in the SBoB subregion mainly in summer (Figure 3.2.2.8a) (Dufour et al., 2010). The more abundant is the albacore, which belongs to the North Atlantic stock. Juveniles up to 5 years old migrate into the NIS subregion from adjacent waters of the Azores during summer. It is an important resource for local fleets. Bluefin tuna adults arrive to the NIS after leaving the spawning areas in the Mediterranean Sea. Although relatively less important in terms of landings, bluefin tuna is also landed by local fleets mainly during summer.



(a) (b)

Figure 3.2.2.8. (a) Representation of albacore (top) and bluefin tuna (bottom) feeding migrations (black arrows) and locations (grey dots) based on catch position from logbooks (Dufour et al., 2010) (b) Total albacore catches reported to ICCAT by gear for the North Atlantic stock (ICCAT, 2010) (http://www.iccat.int/en/)

The historical time-series of albacore catches for the northern North Atlantic stock (mainly Cantabrian Sea and Bay of Biscay) began to decline after 1986, due to a reduction of fishing effort by the traditional surface (troll and baitboat) and longline fisheries (ICCAT, 2010). Some stabilization was observed in the 1990s due to increased effort by new surface fisheries (driftnet and midwater pelagic trawl), with a peak in catches in 2006 (ca. 37.000 t), declining since then below 20.000 t. Some studies suggest that both albacore and bluefin tuna have adapted the timing of migrations and their latitudinal distribution to climate change (Dufour et al., 2010).

Demersal and benthic fish. The diversity of demersal and benthic fish species is quite high in the NIS subregion due to the co-occurrence of subtropical, temperate and boreal species. Species richness, distribution and abundance are determined, however, by the narrowness and topography of the continental shelf. Five types of communities characterize the area, corresponding to species inhabiting the shallow coastal waters, mid shelf, outer shelf, shelf break and slope (OSPAR, 2000). More than 80% of the biomass of demersal species is accounted for by: blue whiting (*Micromesistus potassou*), horse mackerel (*Trachurus trachurus*), dogfish and rays (mainly the lesser-spoted dogfish, *Scyliorhinus canicula*), hake (*Merluccius merluccius*), anglerfish (*Lophius piscatorius* and *L. budegassa*), and megrim (*Lepidorhombus boscii* and *L. whiffiagonis*). Benthic fish present in the NIS subregion include medium-sized species such as *Mullus surmuletus*, *Chelidonichthys gurnardus* and the genus *Callionymus* and flatfish such as species of the genera *Arnoglossus*, *Psetta*, *Bathysolea* and *Solea*.

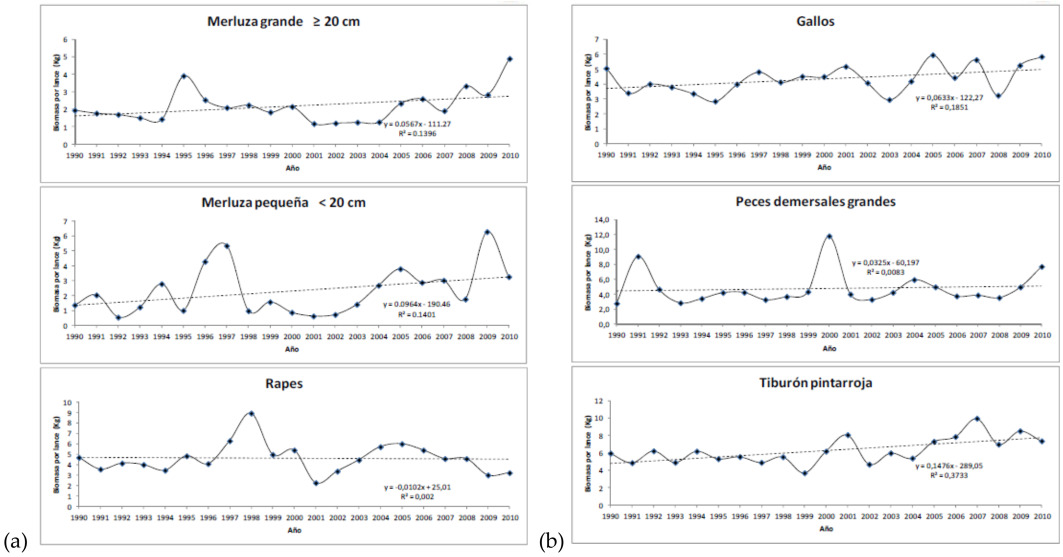


Figure 3.2.2.9. Time-series of the biomass index (kg/trawl) of the main demersal fish (definition and species composition of functional groups in Preciado et al.(2012)) based on trophodynamic interactions –Sánchez and Olaso(2004)- in the NIS subregion. The index is derived from the stock assessment bottom-trawl surveys ('Demersales' survey) carried out in the study area (northern part of the WIS and the whole NIS) in autumn. The group represented are (from top to bottom): (a) Hake larger than 20 cm, hake smaller than 20 cm and anglerfish (*Lophius piscatorius* a *L. budegassa*); (b) Megrim (*Lepidorhombus boscii* and *L. whiffiagonis*), large demersal fish (which include large ichtyophagus fish such as *Chelidonichthys lucernus*, *Conger conger* and *Zeus faber*) and lesser-spotted dogfish (*Scyliorhinus canicula*).

The biomass index for the population of hake in the NIS shows a slightly increasing trend due to the recovery of the populations in the last five years, specially in 2010 when the highest values of the biomass index were reached (Figure 3.2.2.9a) (Preciado et al., 2012). The group of anglerfish shows, apart for the year-to-year fluctuations, a stable biomass index, while the group of merging shows also a stable pattern embedded in a slight increasing trend (Figure 3.2.2.9b). The group of large demersal fish shows a stable pattern apart for two large peaks in the series (in 1991 and 2000) due to exceptional catches of *Z. faber* and *Ch. lucernus* those years. The biomass index for the lesser-spotted dogfish shows a significant increasing trend.

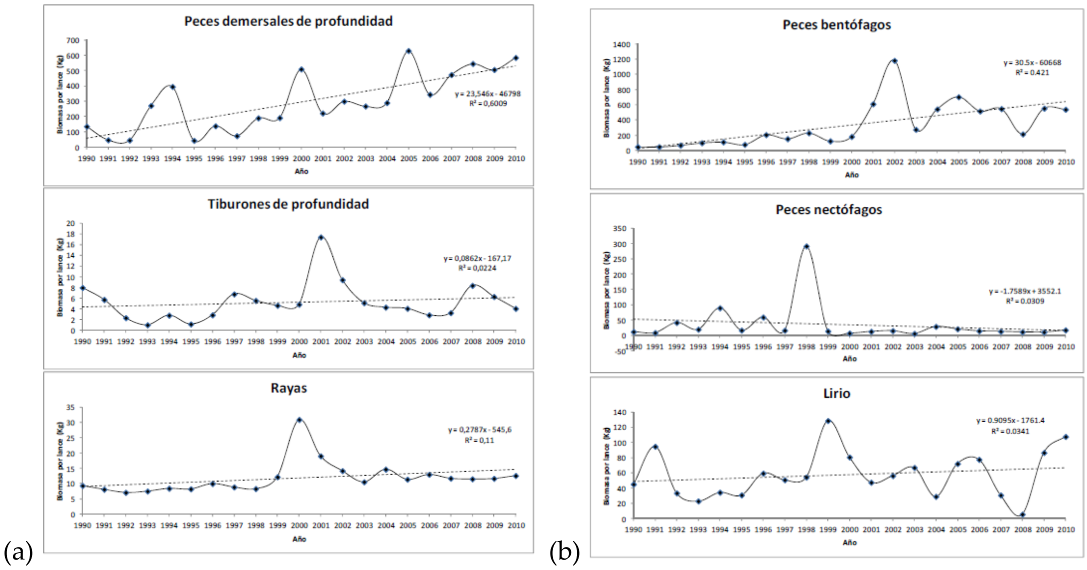


Figure 3.2.2.10. Time-series of the biomass index (kg/trawl) of the relevant functional groups of the demersal fish community (definition and species composition of functional groups in Preciado et al., 2012) in the NIS subregion. The index is derived from the stock assessment bottom-trawl surveys ('Demersales' survey) carried out in the study area (northern part of the WIS and the whole NIS) in autumn. The group represented are (from top to bottom): (a) Deep demersal fish (such as: *Chimaera monstrosa*, *Trachyrincus scabrous*, *Lepidion eques*, *Hydrolagus mirabilis*, *Nezumia aequalis*); Deep sharks (such as *Galeus melastomus*, *Etmopterus spinax*, *Deania spp*.); and Rays (*Raja clavata*, *R. montagui* and *Leucoraja naevus*); (b) Benthophagus fish (such as species form genera *Arnoglassus Callionymus and Chelidonichthys*), Nectophagus fish (such as *Argentina sphyraena*, *Capros aper* or *Macroramphosus scolopax*) and the blue whiting (*Micromesistus poutassou*).

The biomass index of some functional groups of the demersal community exhibits a significant increasing trend. This is the case of the functional groups 'deep demersal' (Figure 3.2.2.10) and 'benthophagus fish' (Preciado et al., 2012). Other groups show a stable value of the index through time, apart from peaks in certain years (e.g. 'Rays' group and blue whiting).

Ecotype: Demersal and benthic invertebrates

Macrofauna (> 1 mm in size) on hard substrata in the upper intertidal zones is dominated by sessile or slow moving species comprising barnacles, limpets, littorinids and topshells. Lower intertidal and subtidal zones are dominated by dense stands of macrophytobenthos communities interspersed with barren areas dominated by sea urchins (*Paracentrotus lividus* and *Echinus esculentus*) which are extensively exploited in the central part of the NIS. Macrofauna on soft substrata is strongly related to grain size, depth and organic matter content of the sediment (OSPAR, 2000). In the NIS subregion two major communities predominate: Macoma which occurs on intertidal muddy sediments and Tellina, a Lusitanian-boreal community that occurs at medium to low tidal levels on fine to medium sandy sediments. Meiofauna (1-0.06 mm in size) is an important component in relation to the trophodynamics of the benthos. It is however the least studied benthic component. Nematodes predominate in areas highly oxygenated and with low bioturbation. Macroinvertebrate benthic communities are particularly diverse at the shelf break (Louzao et al., 2010) or at the Le Danois Bank (Sanchez et al., 2008). The presence of reef-forming cold corals in the Aviles canyon system (Louzao et al., 2010) is one of the main reasons in favour for considering this canyon system a Marine Protected Area to be included in the OSPAR Network.

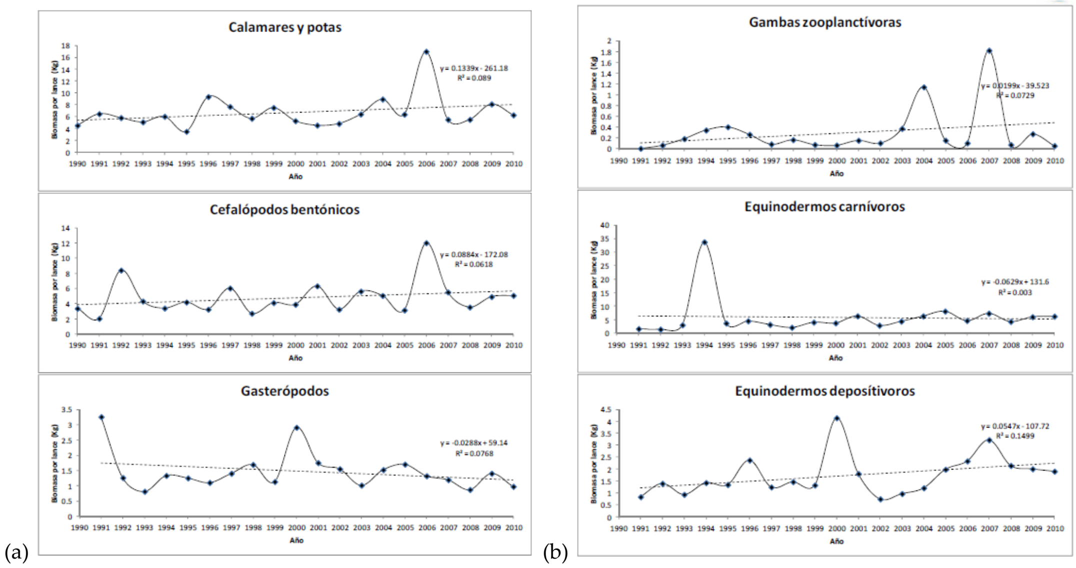


Figure 3.2.2.11. Time-series of the biomass index (kg/trawl) of some functional groups of the ecotype of demersal / benthic invertebrates (definition and species composition of functional groups in Preciado et al., 2012) in the NIS subregion. The index is derived from the stock assessment bottom-trawl surveys ('Demersales' survey) carried out in the study area (northern part of the WIS and the whole NIS) in autumn. The group represented are (from top to bottom): (a) Squids (such as *Alloteuthis spp.*, *Illex coindeti* and *Loligo spp*); Benthic cephalopods (such as *Eledone cirrhosa, Octopus vulgaris, Sepia elegans* and *Sepia officinalis*); Gastropods (such as *Argobuccinum olearium, Munida intermedia, M. Iris, Pagurus alatus* and *P. bernhardus*); (b) Zooplanktophagus shrimps (such as *Acantephyra purpurea*, *Pasiphaea multidentata* and *P. sivado*), Carnivorous echinoderms (such as *Anseropoda placenta, Astropecten auranticus* and *Echinus esculentus*) and suspension-feeders echinoderms (such as *Brissopsis lyrifera, Echinocardium spp.* and *Spatangus purpureus*).

The biomass index for the group of molluscs keeps stable during the analysed period (Figure 3.2.2.11a). The index for the gastropods, an important group since it includes vulnerable / sensitive species which in some cases are under threat, shows a decreasing trend that must however be taken cautiously due to the large value of the index at the beginning of the series (owing to high abundances of *Colus gracilis* observed in the survey carried out in 1991) (Preciado et al., 2012).

The group of crustaceans, except for the case of the langoustine (*Nephrops norvegicus*) which is in the NIS below the precautionary limit of biomass (ICES, 2011), presents in general terms stable values of the biomass index (Figure 3.2.2.11b) (Preciado et al., 2012).

Ecotype: Macrophytobenthos

The biogeographical distribution of macroalgal communities along the NIS is a conspicuous ecological pattern coherent with the hydrographic Western-Eastern gradient. The most abundant and characteristic species are: *Ascophyllum nodosum*, *Bifurcaria bifurcata*, *Codium tomentosum*, *Cystoseira spp.*, *Chondrus crispus*, *Fucus serratus*, *Fucus vesiculosus*, *Fucus spiralis*, *Gelidium sesquipedale*, *Himanthalia elongata*, *Laminaria ochroleuca*, *Laminaria hyperborea*, *Pelvetia canaliculata* and *Saccorhiza polischydes*.

Boreo-Atlantic species, abundant on the Atlantic coast in the northern part of the Western Iberian subregion (WIS) are progressively substituted by species with meridional affinity towards the inner part of the NIS subregion (e.g. Anadón and Niell, 1981). Several species of large brown algae have a distinct distributional boundary in the central part of the NIS (around Cape Peñas, at ca. 6°W), including *Fucus serratus*, *Laminaria ochroleuca*, *Himanthalia elongata* (Luning 1990). Nevertheless, this biogeographical pattern has in turn evolved in time towards a progressive substitution of Boreo-Atlantic species by a complex assemblage of small sized ephemeral species with southern affinities all over the NIS, particularly conspicuous in the last years (Viejo et al., 2010; Fernández, 2011) (Figure 3.2.2.12).

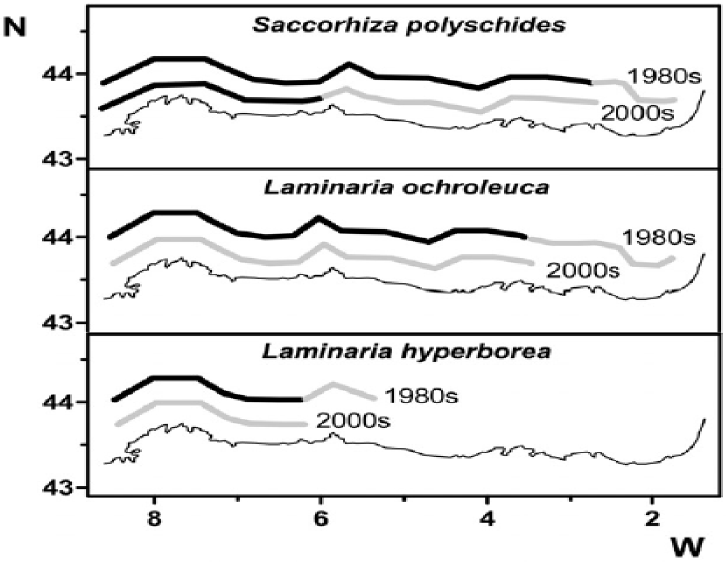


Figure 3.2.2.12. Alongshelf evolution of the main species of brown algal species in the NIS subregion (Fernández, 2011). See also Velasco et al. (2012).

Ecotype: Top predators (marine birds and mammals)

This area is an important migration corridor for seabirds during late summer and autumn. More than a million of seabirds from at least 16 species have been recorded such as the black scoter (*Melanitta nigra*), the Cory's shearwater (*Calonectris diomedea*), the great shearwaterhttp://www.birdlife.org/datazone/speciesfactsheet.php?id=3932 (*Puffinus gravis*), the Sooty shearwater (*Puffinus griseus*), Manx shearwater (*P. puffinus*), Balearic shearwater (*P. mauretanicus*), Northern gannet (*Morus bassanus*), Great skua (*Stercorarius skua*), Arctic skua (*S. parasiticus*), Pomarine skua (*S. pomarinus*), Mediterranean gull (*Larus melanocephalus*), Lesser Black-backed gull (*L. fuscus*), Black-legged Kittiwake (*Rissa tridactyla*), Sandwich tern (*Sterna sandvicensis*), Larus Common tern (*S. hirundo*) and Little tern (*S. albifrons*) (Arcos et al. 2009). The western sector of NIS (Estaca de Bares-Cabo Peñas) is especially important for certain species (e.g. Balearic and Manx shearwaters, Northern Gannet, Great skua, Sandwich tern) since a significant percentage of their global populations visit this area (Arcos et al. 2009). Due to this high concentration of seabirds, this biogeographic area also encompass important bird areas in the pelagic realm, as well as marine extension of breeding colonies of several species such as the Cory´s shearwater, the European shag (*Phalacrocorax aristotelis*) (Figure 3.2.2.13a), the European storm-petrel (*Hydrobates pelagicus*) (Figure 3.2.2.13b), the common tern and the yellow-legged gull (*Larus michahellis*). This marine area is an especially important breeding area for the Atlantic subspecies of the European storm petrel in the Iberian Atlantic coast (Arcos et al. 2009).

(a) (b)

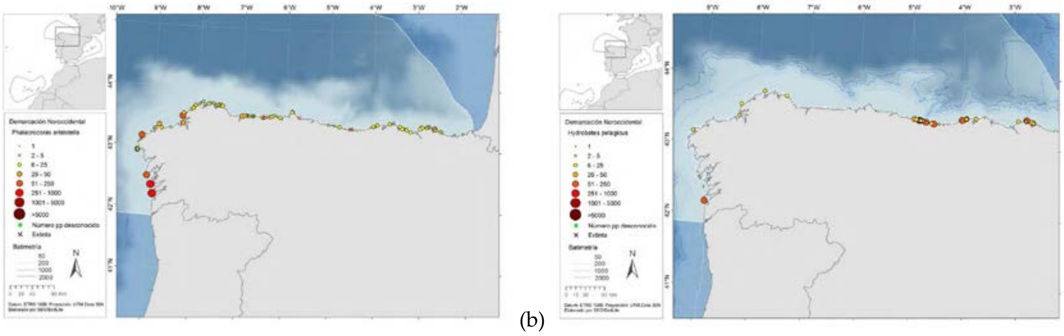


Figure 3.2.2.13. Distribution and size of the colonies of (a) European shag (*Phalacrocorax aristotelis*) and (b) European storm-petrel (*Hydrobates pelagicus*). From Arcos et al. (2012)

The waters of the NIS are home to a wide variety of cetaceans and seabirds. A total of 14 species of cetaceans have been recorded of which the most abundant are the common dolphin (*Delphinus delphis*) in shelf waters and the bottlenose dolphins (*Tursiops truncatus*) in the coastal areas, as well as the striped dolphin (*Stenella coeruleoalba*) and the long-finned pilot whale (*Globicephala melas*) (Ruano et al., 2007). Other species found in the area include the harbour porpoise (*Phocoena phocoena*), the Iberian population of which is genetically distinct (Fontaine et al., 2007).

3.3 Human impacts

The main human impacts, pressures and activities affecting the NIS subregion are summarized below, extracted from the document concerning the analysis of pressures and impacts in the North Atlantic demarcation of Spanish MSFD (Capote et al., 2012, Table 1 of the document).

Impact / Pressure			Sector / Human Activity	MSFD Descriptor
Physical losses	Modification of the bottom relief and/or burial	Extraction of solids	Coastal protection, activity in harbours	1, 6
		Disposal of dredging material	Activity in harbours	
		Regeneration of beaches	Coastal protection and tourism	
		Cables and pipelines	Transport, telecommunications, cleaning up	
		Artificial reefs	Coastal protection, environmental management, fisheries management	
	Sealing	Defence and harbour infrastructures	Coastal protection, activity in harbours	
		Prospection / extraction hydrocarbons	Energetic industries	
		Artificial reefs	Environmental management, fisheries management	
		Wind farms	Energetic industries	
Physical damage	Modification of sedimentation	Defence and harbour infrastructures	Coastal protection, activity in harbours	
		Control of river fluxes	Water supply and agriculture	
		Regeneration of beaches	Coastal protection and tourism	
		Platforms aquaculture (mainly mussel culture)	Aquaculture	
		Disposal of dredging material	Activity in harbours	
		Artificial reefs	Coastal protection, environmental management, fisheries management	
		Extraction of solids	Coastal protection, activity in harbours	
	Abrasion	Bottom fishing trawl	Commercial fisheries	
		Anchoring and deployments	Maritime transport, recreation, commercial fisheries	
		Extraction of solids	Coastal protection, activity in harbours	
		Prospection / extraction hydrocarbons	Energetic industries	
		Diving	Tourism, fishing	
	Selective extraction	Extraction of solids	Coastal protection, activity in harbours	
		Prospection / extraction hydrocarbons	Energetic industries	

Other physical perturbations	Underwater noise	Cables and pipelines	Transport, telecommunications, cleaning up	1, 11
		Prospection / extraction hydrocarbons	Energetic industries	
		Seismic prospection	Research	
		Disposal of dredging material	Activity in harbours	
		Extraction of solids	Coastal protection, activity in harbours	
		Defence and harbour infrastructures	Coastal protection, activity in harbours	
		Navigation and harbour infrastructures	Transport	
	Marine wastes	Marine litter	Tourism, commercial fisheries, transport, recreational activities, management of waste material	1, 6, 10
		Shipwreck	Commercial fisheries, transport, recreation	
		Obsolescence weapons and military material	Military activities	
	Other physical perturbations	Permanent offshore structures	Security, industrial activities	1, 4, 6
		Extraction of solids	Coastal protection, activity in harbours and in relation to offshore platforms	
		CO2 storage	Energetic industries and amelioration of climate change impacts	
		Seawater extraction	Desalinization, salting industries, refrigeration	
Interference with hydrographic processes	Significant modifications of thermal regime	Thermal dumping	Industrial activities	7
	Significant modifications of haline regime	Brine dumping	Desalinization	
		Freshwater disposal	Sewage treatment	
		Regulation river fluxes	Water supply, agriculture, energy production	
Contamination by hazardous substances	Introduction of chemicals	Accidental spill	Industrial and transport activities	8, 9
		Diffuse contamination by atmospheric deposition	Industrial and transport activities	
		Diffuse contamination by continental run-off	Agriculture, mining and transport industries.	
		Supply from river	Agriculture, mining and transport.	
		Dumping of liquids	Industrial activities and sewage treatment	

		Dumping of solids	Harbour activities	
	Introduction of radionuclei	Direct dumping	Energetic industries	
		Dumping through run-off and ricers	Energetic industries	
Accumulation of nutrients and organic substances	Input of fertilizers and other nitrogen- and phosphorous-rich substances	Direct inputs of liquid and solid substances	Industrial activities and sewage treatment	1, 5, 6, 8, 9
		Inputs from rivers	Industry, agriculture and sewage treatment	
		Growth in captivity of fish and shellfish	Aquaculture	
		Diffuse contamination by atmospheric deposition	Industrial and transport activities	
		Diffuse contamination by continental run-off	Agriculture, mining and transport industries.	
	Input of organic substances	Growth in captivity of fish and shellfish	Aquaculture	
		Inputs from rivers	Industry, agriculture and sewage treatment	
		Byctach and accidental captures	Fishing activities	
		Urban water residuals	Sewage treatment	
		Dredging material	Harbour activities	
		Extraction of solids	Coastal protection, activity in harbours and in relation to offshore platforms	
		Regeneration of beaches	Coastal protection and tourism	
Biological perturbations	Introduction of microbial pathogens	Urban residual water	Sewage treatment	1, 9
		Ballast water	Marine transport and traffic	
		Bathing zones	Recreational activities	
		Inputs from rivers	Sewage treatment	
		Growth in captivity of fish and shellfish	Aquaculture	
	Introduction of aloctonous species	Ships and anchors	Maritime traffic and transport	1, 2, 3, 4, 6
		Ballast water	Maritime traffic	
		Growth in captivity of fish and shellfish	Aquaculture	
		Offshore platforms	Industrial activities	
		Disposal of dredging material	Harbour activities	
		Escape from aquariums	Leisure and research activities	
	Selective extraction	Commercial fish species	Commercial fisheries	3, 4

	Growth in captivity of fish and shellfish	Aquaculture
	Commercial shellfish	Commercial shellfisheries
	Recreational capture of fish species	Leisure activities and tourism
	Bycatch	Commercial fisheries

3.4 Activity and Pressure

Physical impacts

Dredging (Figure 3.4.2.1)

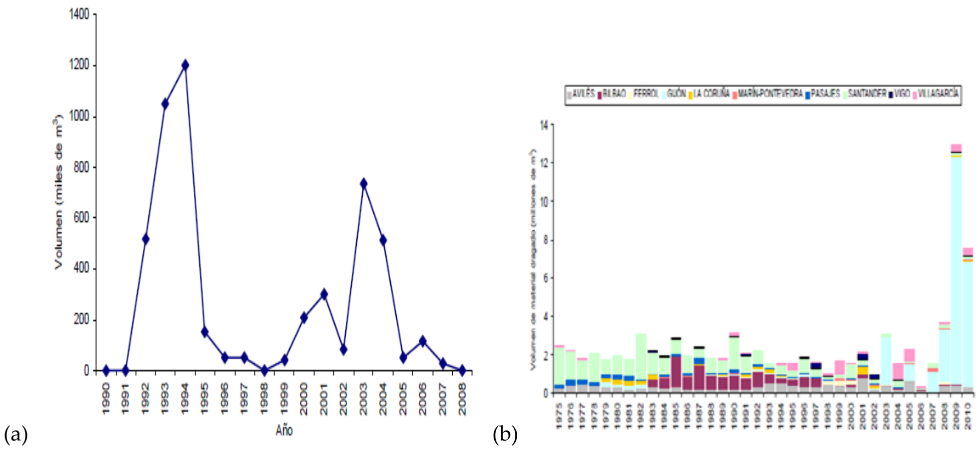


Figure 3.4.2.1. (a) Annual volume of sand extracted in the NIS subregion. (b) Annul volume of dredging in the main harbours of the NIS subregion (Capote et al., 2012).

Cables and pipelines: Figure 3.4.3.2.

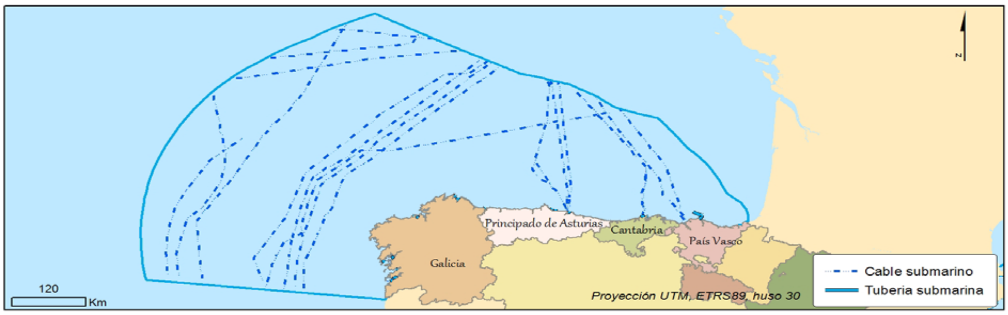


Figure 3.4.2.2. Location of cables and pipelines in the northern WIS and NIS subregions (Capote et al., 2012).

Artificial coastline and reefs: Figure 3.4.3.3.

Figure 3.4.2.3. Location of artificial coastline (red) and artificial reefs (blue) in the northern WIS and NIS subregions (Capote et al., 2012).

Wind farms: Figure 3.4.3.4.

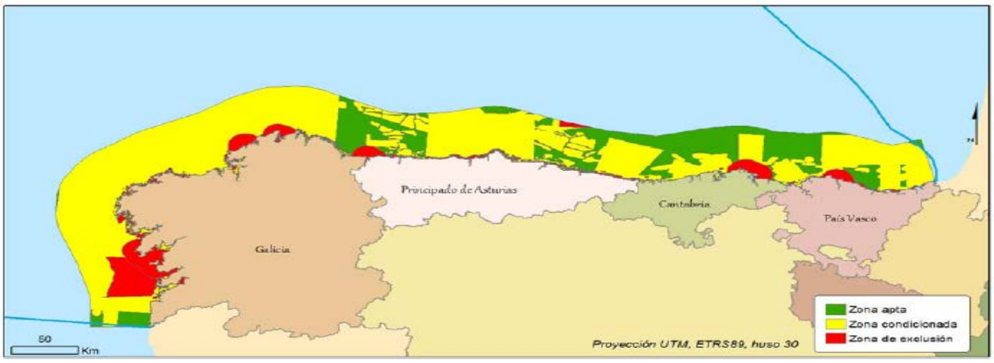
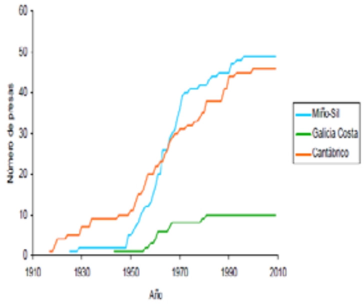
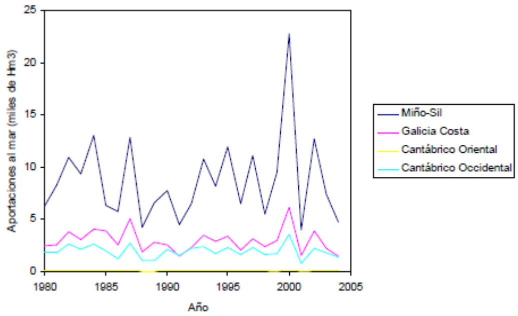


Figure 3.4.2.4. Zones established in the northern WIS and NIS subregions for the installation (Capote et al., 2012) of offshore wind farms (available, conditioned and forbidden zones).

Dams; modification of continental inputs through from rivers: Figure 3.4.2.5



(a)



(b)

Figure 3.4.2.5. (a) Evolution of the numbers of dams in the drainage basins that outflow in the northern WIS (Miño-Sil) and in the NIS (Cantabrico). (b) Time-series of freshwater discharges from the main rivers that outflow on the northern WIS and NIS subregions (Capote et al., 2012).

Abrasion by bottom trawl: Figure 3.4.2.6.

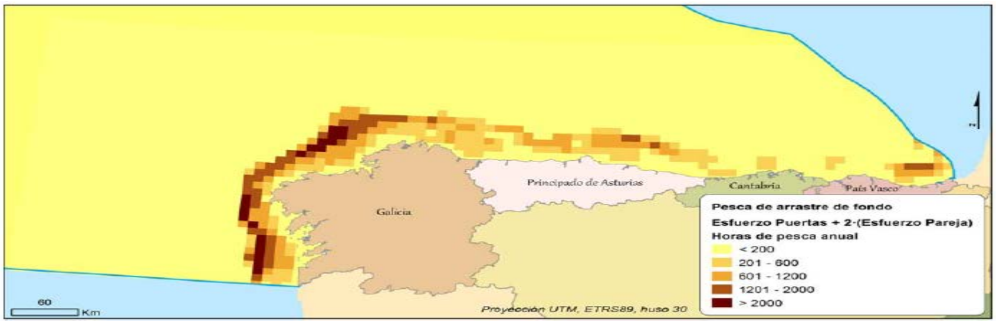


Figure 3.4.2.6. Fishing effort (in hours of bottom trawl per year) in the northern WIS and in the NIS (Capote et al., 2012).

Chemical impacts

Concentration of PCBs: Figure 3.4.2.7.

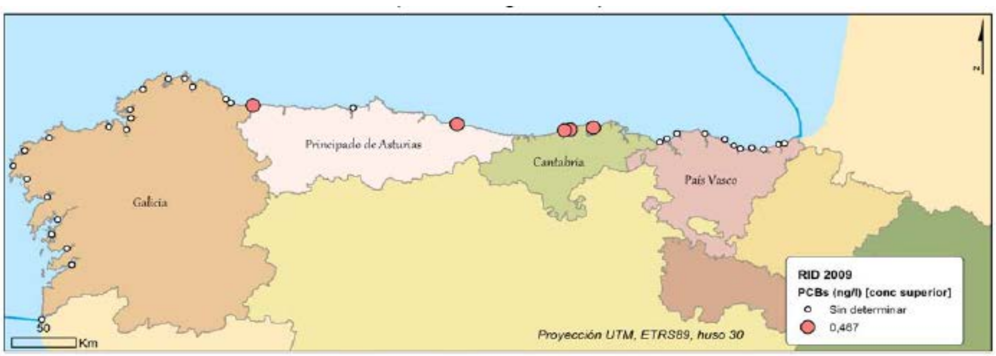


Figure 3.4.2.7. Maximum concentration of PCBs in year 2009 outflow from the main rivers (Capote et al., 2012).

Concentration of cadmium (Cd): Figure 3.4.2.8.

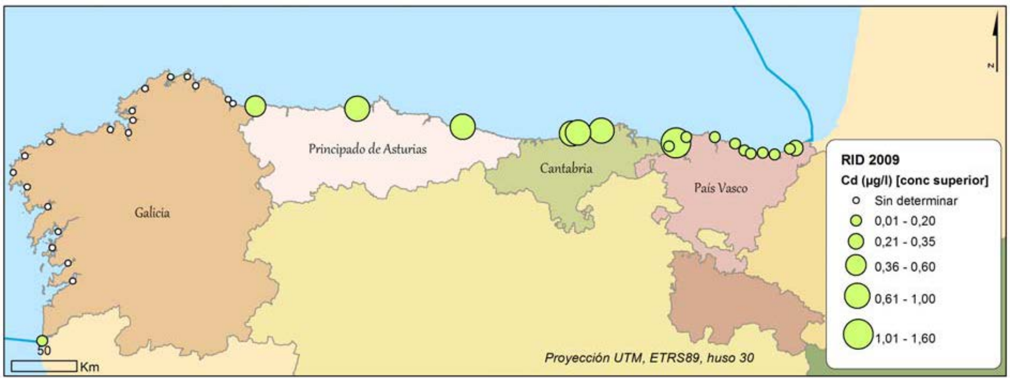


Figure 3.4.2.7. Maximum concentration of cadmium (Cd) in year 2009 outflow from the main rivers (Capote et al., 2012).

Concentration of mercury (Hg): Figure 3.4.2.8.

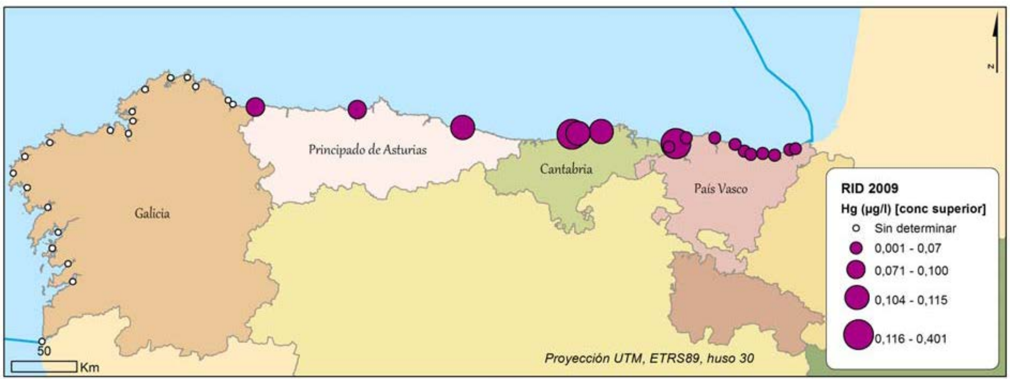


Figure 3.4.2.8. Maximum concentration of mercury (Hg) in year 2009 outflow from the main rivers (Capote et al., 2012).

Concentration of cooper (Cu): Figure 3.4.2.9.

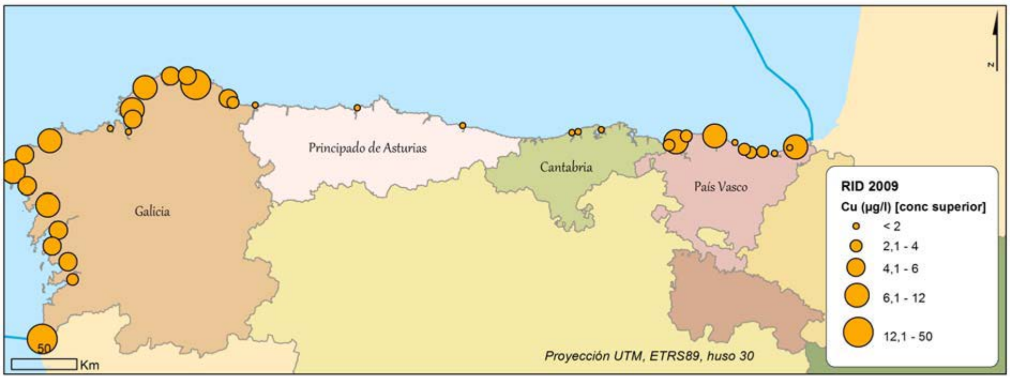


Figure 3.4.2.9.. Maximum concentration of cooper (Cu) in year 2009 outflow from the main rivers (Capote et al., 2012).

Concentration of lead (Pb): Figure 3.4.2.10.

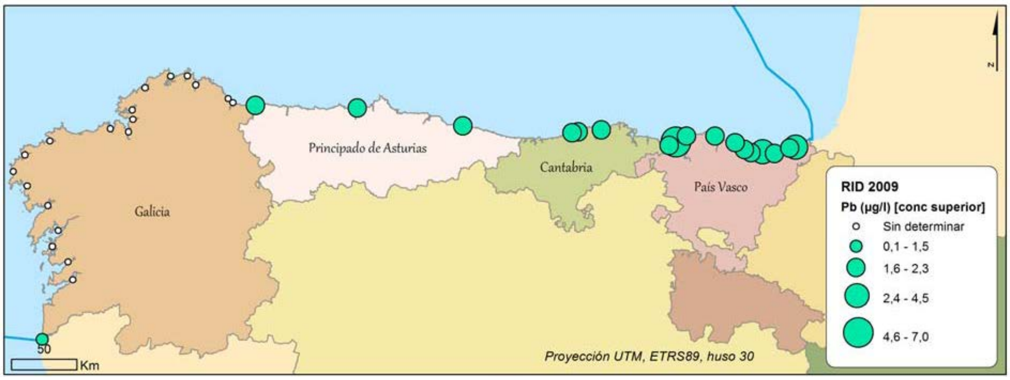


Figure 3.4.2.10. Maximum concentration of cooper (Cu) in year 2009 outflow from the main rivers (Capote et al., 2012).

Concentration of total nitrogen: Figure 3.4.2.11

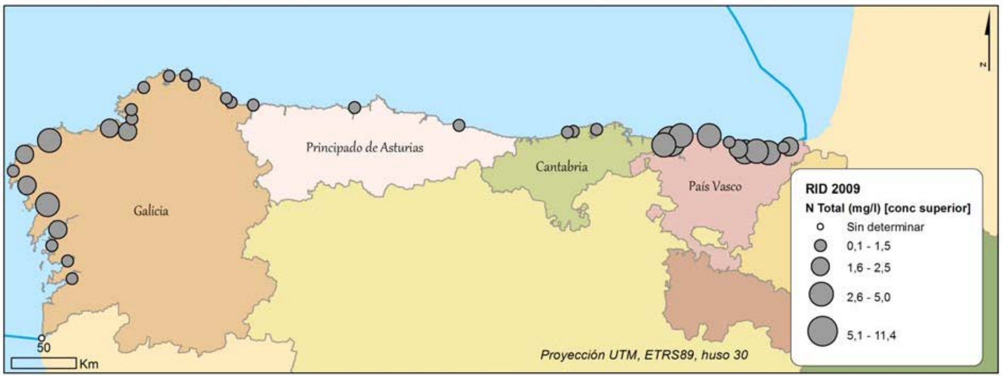


Figure 3.4.2.11. Maximum concentration of total nitrogen in year 2009 outflow from the main rivers (Capote et al., 2012).

Concentration of total phosphorus: Figure 3.4.2.12

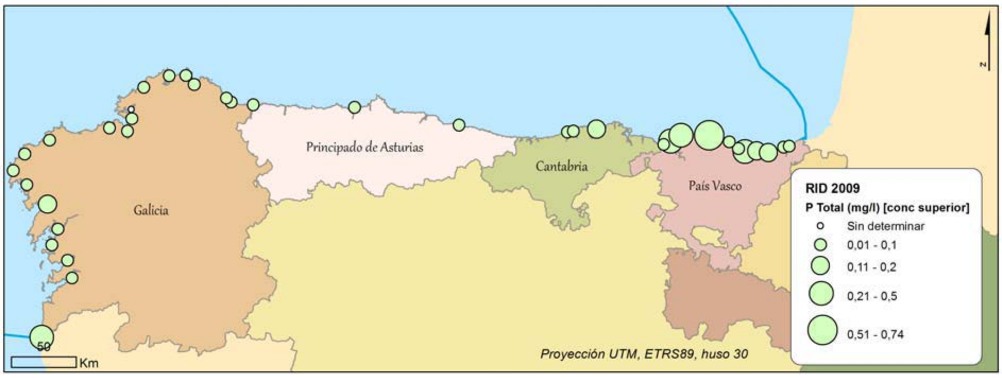


Figure 3.4.2.12. Maximum concentration of total phosphorus in year 2009 outflow from the main rivers (Capote et al., 2012).

Biological impacts

Aquaculture industries: Figure 3.4.2.13.

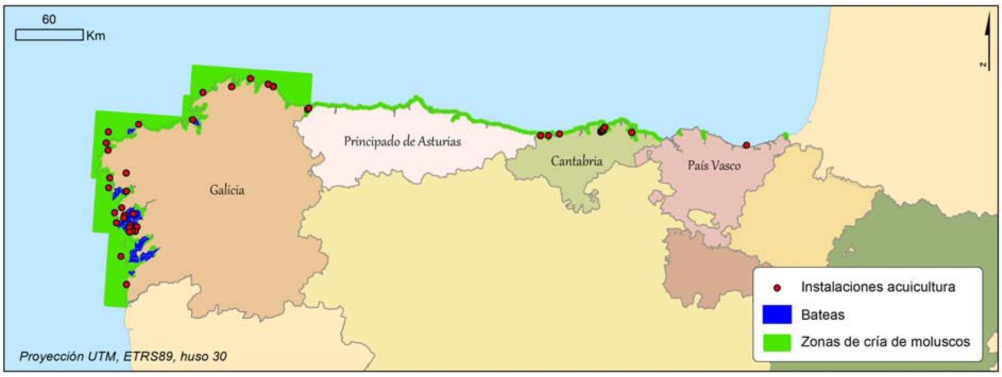
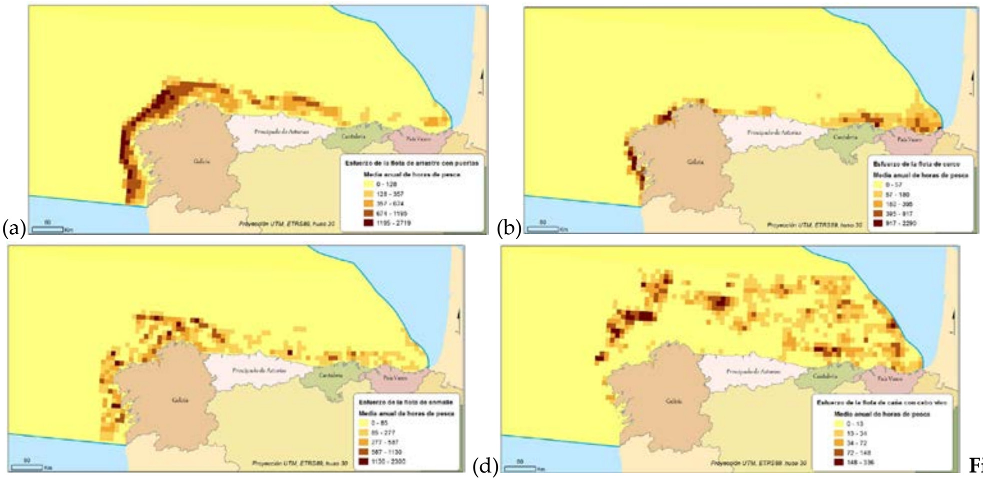


Figure 3.4.2.13. Location of main aquaculture farms (fish farms –red dots; mussel rafts –blue; shellfish culture -green) (Capote et al., 2012).

Fishing activities: Figure 3.4.2.14.



(a) (b) (c) (d)

Figure 3.4.2.14. Spatial distribution of fishing effort in the northern WIS and NIS subregions by gear (a) bottom trawl; (b) purse-seiner; (c) gillnet; (d) life bait.

3.5 Pressure

Modification of bottom relief: Figure 3.5.2.1

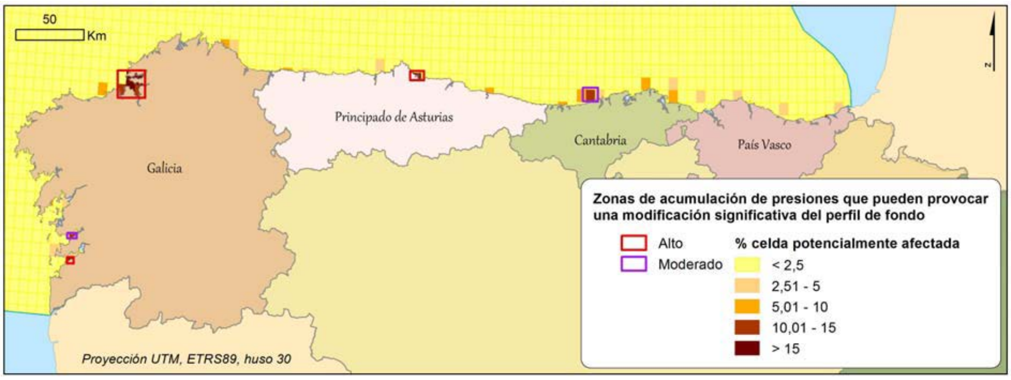


Figure 3.5.2.1. Spatial distribution of zones of accumulated pressure which can imply a modification of bottom relief (Capote et al., 2012).

Alteration of hydrologic and/or sedimentation regimes: Figure 3.5.2.2.

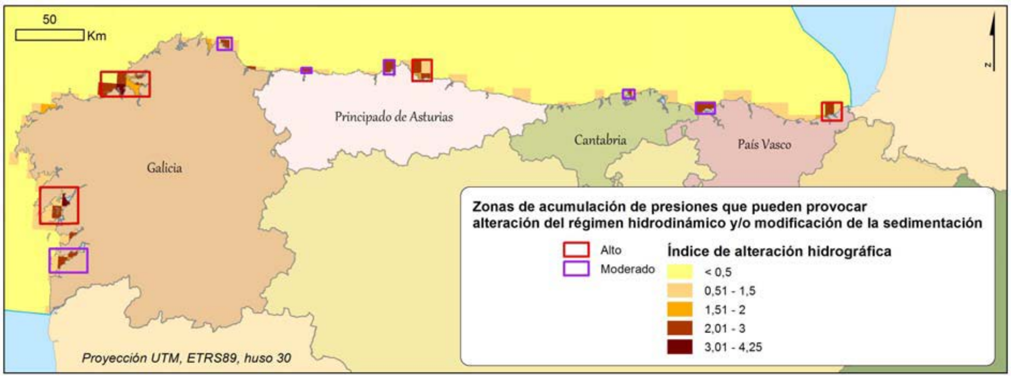


Figure 3.5.2.2. Spatial distribution of zones of accumulated pressure which can imply the alteration of the hydrological and/or sedimentation regimes (Capote et al., 2012).

Physical abrasion: Figure 3.5.2.3

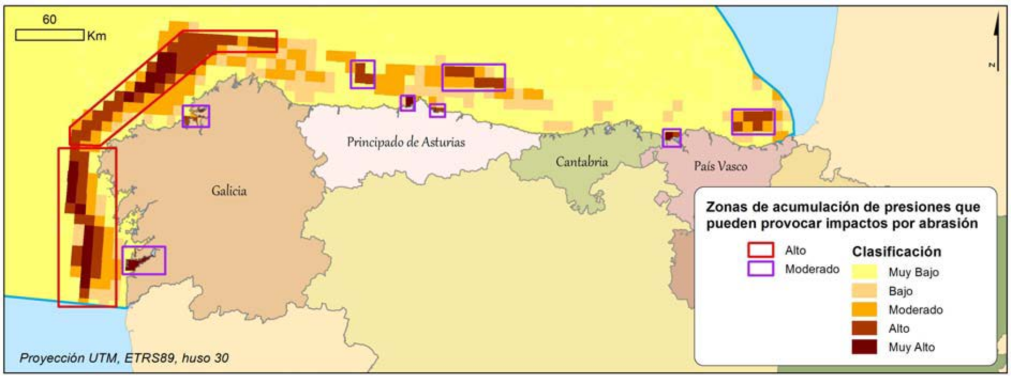


Figure 3.5.2.3. Spatial distribution of zones of accumulated pressure which can imply the physical abrasion of the bottom (Capote et al., 2012).

Underwater noise: Figure 3.5.2.4

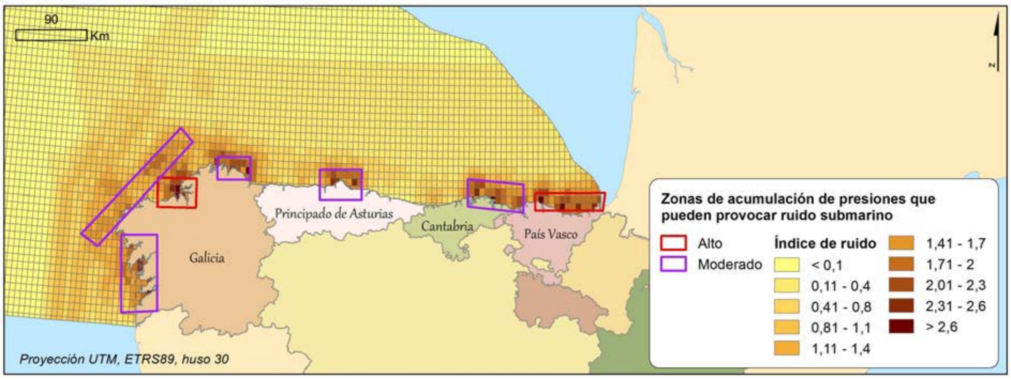


Figure 3.5.2.4. Spatial distribution of zones of accumulated pressure which can be subject to underwater noise (Capote et al., 2012).

Waste disposal from land: Figure 3.5.2.5

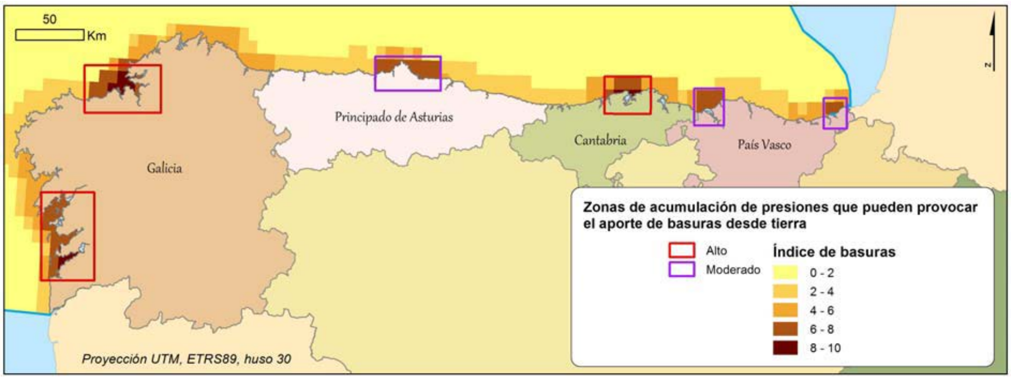


Figure 3.5.2.5. Spatial distribution of zones of accumulated pressure which can be subject to waste disposal from land (Capote et al., 2012).

Waste disposal from the sea: Figure 3.5.2.6

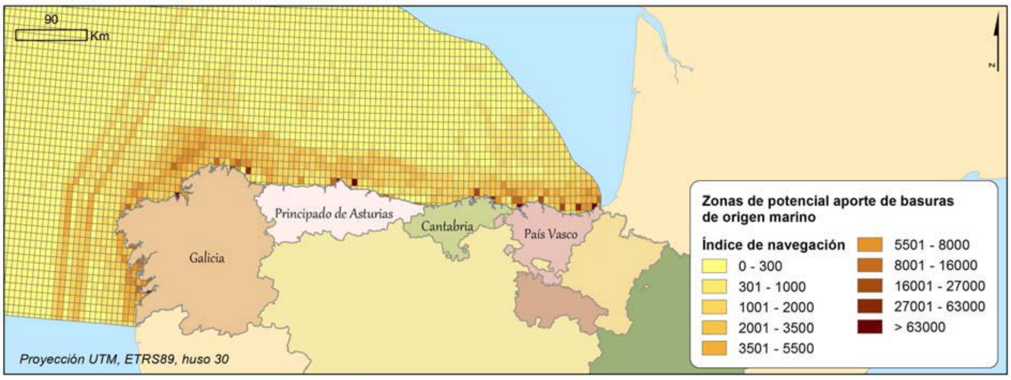


Figure 3.5.2.6. Spatial distribution of zones of accumulated pressure which can be subject to waste disposal from sea (Capote et al., 2012).

Alteration of thermal regime: Figure 3.5.2.7

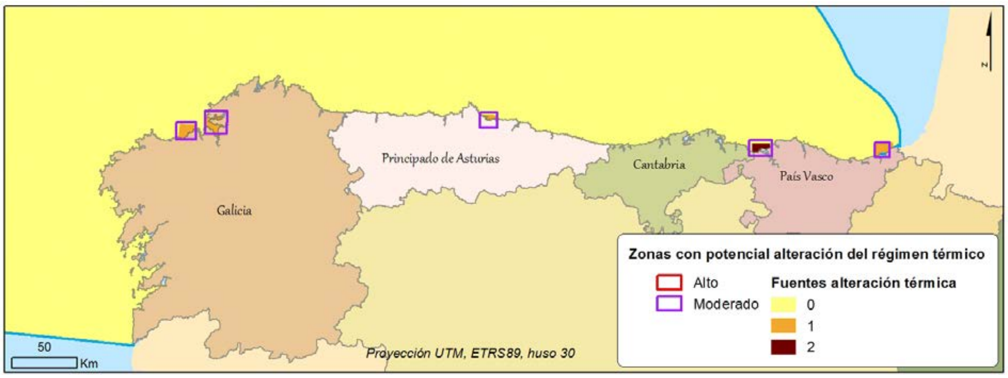


Figure 3.5.2.7. Spatial distribution of zones of accumulated pressure which can be subject to alteration of thermal regime (Capote et al., 2012).

Contaminants: Figure 3.5.2.8

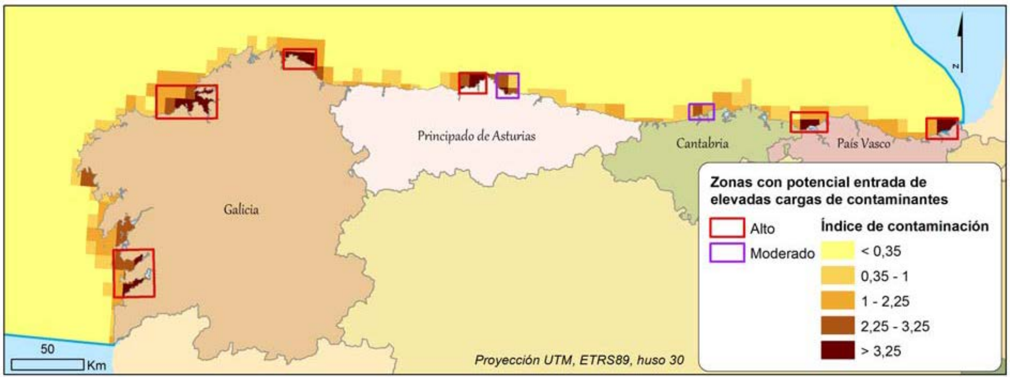


Figure 3.5.2.8. Spatial distribution of zones of accumulated pressure which can be subject to the input of contaminants (Capote et al., 2012).

Nutrients (eutrophication): Figure 3.5.2.9

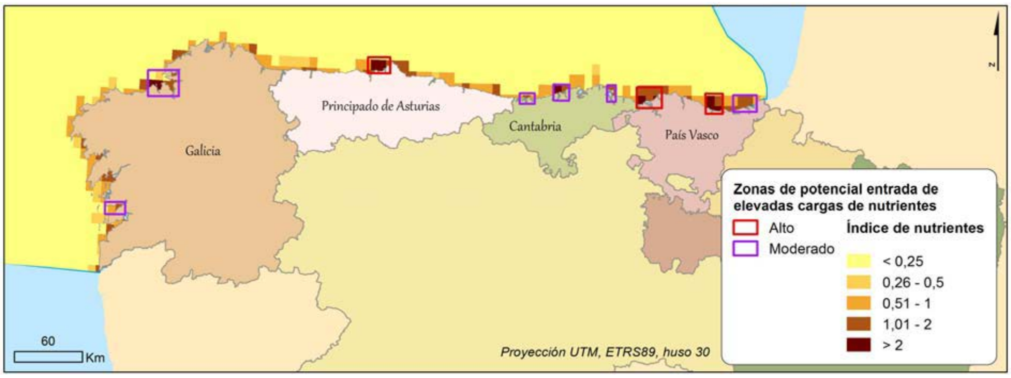


Figure 3.5.2.9. Spatial distribution of zones of accumulated pressure which can be subject to the input of nutrients (eutrophication) (Capote et al., 2012).

Pathogens: Figure 3.5.2.10

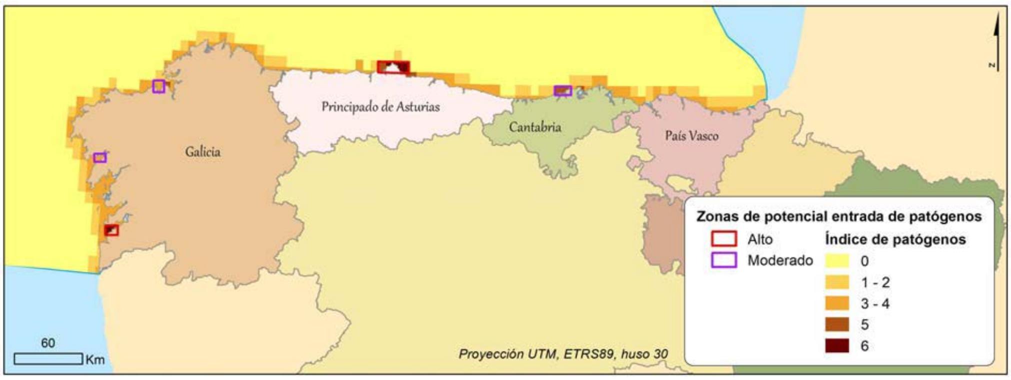


Figure 3.5.2.10. Spatial distribution of zones of accumulated pressure which can be subject to the input of pathogens micro-organisms (Capote et al., 2012).

Non-indigenous / invasive species: Figure 3.5.2.11

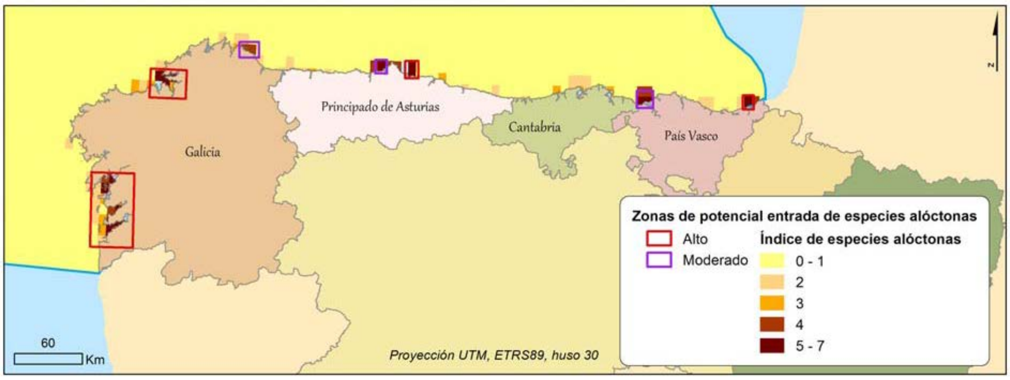


Figure 3.5.2.11. Spatial distribution of zones of accumulated pressure which can be subject to the exposure to non-indigenous / invasive species(Capote et al., 2012).

Catches by harbour: Figure 3.5.2.12

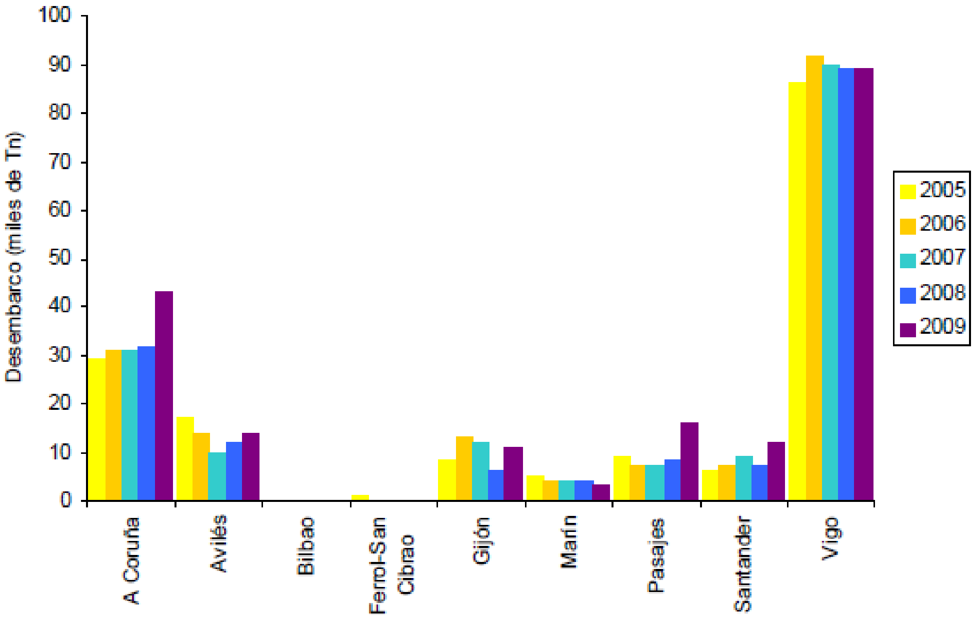


Figure 3.5.2.12. Time-series (2005-2009) of catches in the main harbours of the northern WIS and in the NIS (Capote et al., 2012).

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4 Western Iberia subregion

4.1 Key signals

4.1.1 Physical and chemical oceanography

Circulation

The circulation of the west coast of the Iberian Peninsula is characterized by a complex current system subject to strong seasonality and mesoscale variability, showing reversing patterns between summer and winter in the upper layers of the shelf and slope (e.g. Barton, 1998; Peliz *et al.,* 2005, Ruiz Villareal *et al.*, 2006).

The Atlantic West coast of Iberian peninsula (Figure 4.1) shows a north–south orientation causing winds from the north to produce offshore transport. During spring and summer northerly winds along the coast are dominant causing coastal upwelling and producing a southward current at the surface and a northward undercurrent at the slope (Fiúza *et al.,* 1982; Haynes and Barton, 1990; Alvarez-Salgado, *et al.,* 2003; Peliz *et al*., 2005; Mason *et al.*, 2005).

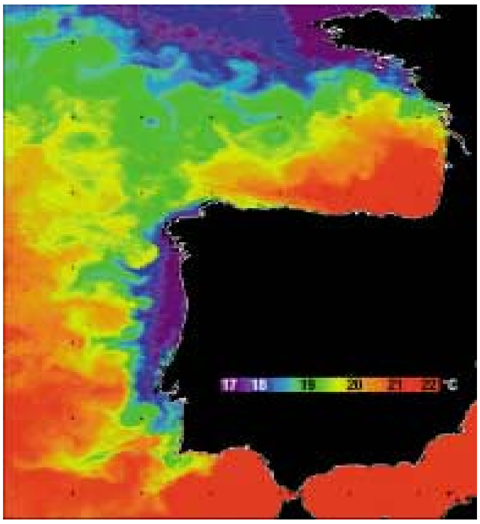

Figure 4.1. Composite sea surface temperature image showing upwelling near the western Iberian coast (2–8 Aug 1998) (Source: OSPAR 2000).

The intermediate layers are mainly occupied by a poleward flow of Mediterranean Water (MW), which tends to contour the southwestern slope of the Iberia (Ambar and Howe, 1979), generating mesoscale features called Meddies (e.g. Serra and Ambar, 2002), which can transport salty and warm MW over great distance. The poleward flow observed along the west coast of the Iberian Peninsula (Figure 4.2) is characterized by a transport of warm and salty water (typical surface anomalies, 1–1.5C and 0.1–0.3 in salinity) with velocities up to some 0.2–0.3 m s_1 reported by Haynes and Barton (1990) and Frouin et al. (1990). From the point of view of hydrological fields, this current, recently reviewed by Peliz *et al*. (2005), is characterized by a coastal downwelling of the isopycnal field of up to 200 m in an across-shore distance of about 40 km.

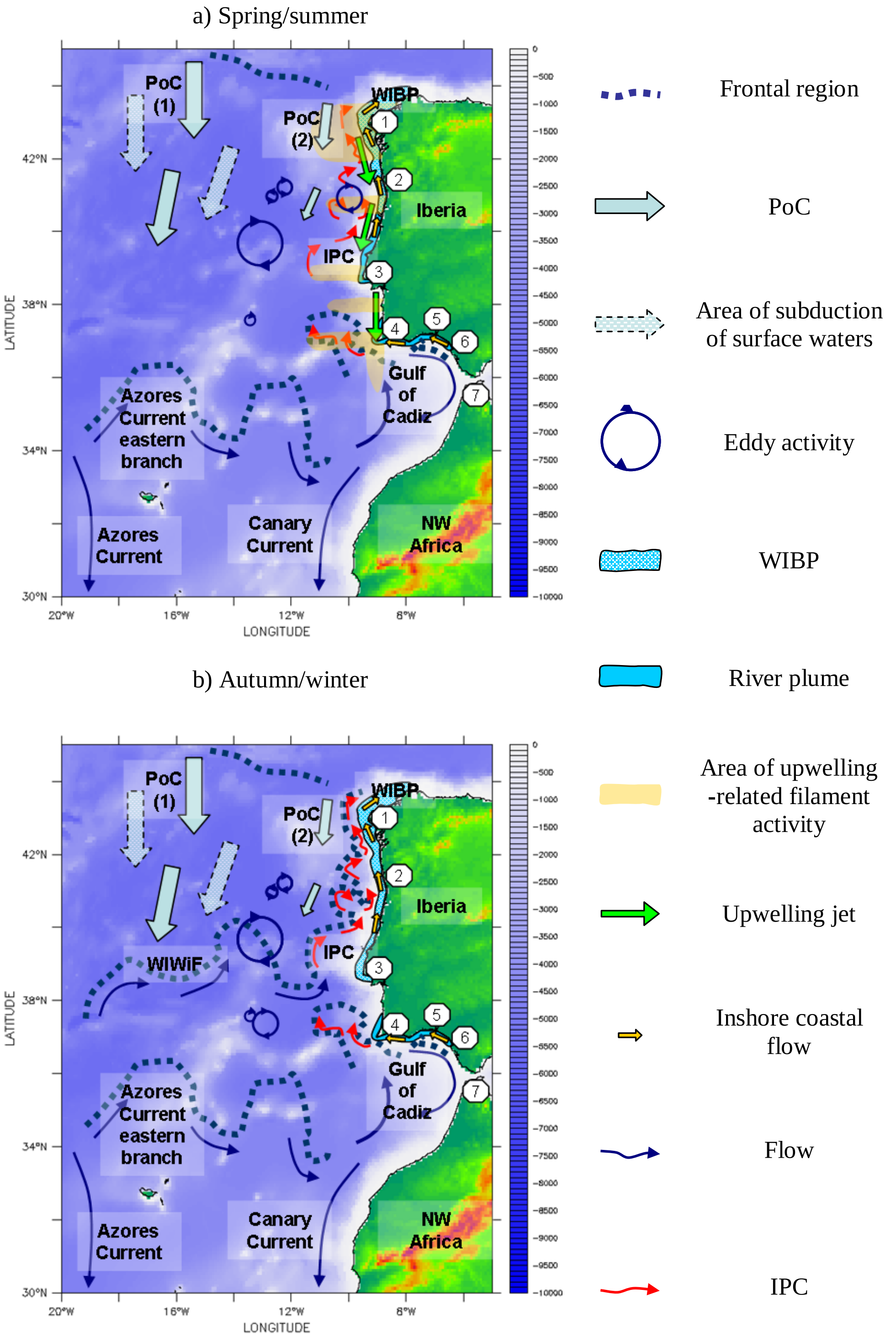

Figure 4.2. The western Iberia and Gulf of Cadiz regimes in a) spring and summer, and b) autumn and winter. 1) Cape Finisterre; 2) River Douro; 3) Cabo da Roca; 4) Cape St Vincent; 5) Guadiana River; 6) Guadalquivir River; 7) Strait of Gibraltar. PoC - southward Portugal Current, WIBP - Western Iberia Buoyant Plume, IPC - Iberian Poleward Current . (Adapted from Peliz *et al.* 2002; Peliz *et al.* 2005)

The predominantly equatorward winds observed in summer off West Iberia, drive an offshore Ekman transport and force the upwelling of colder, nutrient-rich, subsurface waters along coast. Satellite-derived sea surface temperature (SST), have been used in the past decades to describe the upwelling patterns in the region, owing to the clear thermal contrast between the cold, vertically mixed, upwelled waters, typically found over the shelf, and the thermally stratified oceanic waters.

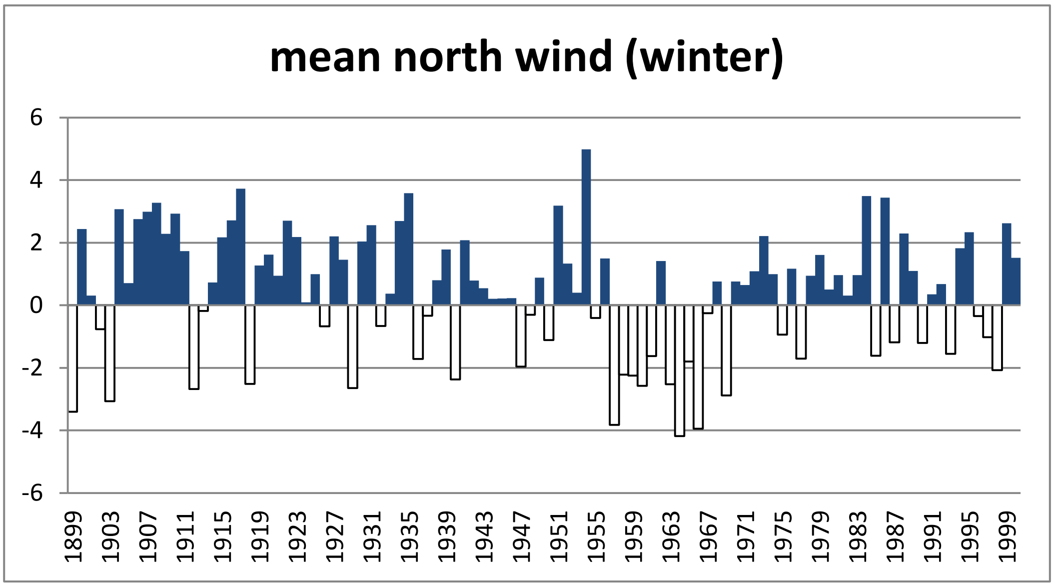

Figure 4.3. Mean north wind during Winter (January-March) from NCAR, reanalysis data ((5ºx5º grid 30-50ºN, 25-5ºW with centre 40ºN and 10ºW), unit:m/s. (courtesy of A.M. Santos, IPMA)

When equatorward winds start to prevail (late spring/early summer), a narrow band of cold water of relatively uniform width is observed along the coast, and small-scale (20–30 km) perturbations are usually seen along the thermal front, (Relvas, *et al.*, 2007). Approximately one month after the beginning of upwelling favorable winds, major filament structures start to develop, associated with offshore currents reaching 0.5 m s_1, leading to the classical picture of what is usually called ''fully developed upwelling'' where several cold water filaments are seen to extend more than 200 km offshore, (Relvas, *et al.*, 2007). The new production of an entire upwelling season could be entirely exported to the open ocean by upwelling filaments (Arístegui et al., 2006) and organic matter sedimentation could take place far away from the upwelling source. However, the results of observations made by Barton et al. (2001) showed that a portion of the water transported off shelf recirculated back to the shelf on time-scales of about 1 month, and this could have implications for the retention of biological material on the shelf (e.g. fish larvae). According to Relvas et al., (2007) the frontal band extending along all the Algarve coast indicates that the eastward advection of the cold water around Cape São Vicente may be linked to a larger water inflow into the Gulf of Cadiz, i.e. the eastern branch of the Azores Current.

During winter the prevailing winds in the west coast of Iberian Peninsula (Figure 4.3) are mainly southwesterlies, and the atmospheric circulation is dominated by the eastward displacement of cyclonic perturbations and their associated frontal systems (Relvas *et al.*, 2007) However, in some years the presence of episodic atmospheric anticyclonic circulation (the Azores High) could give rise to northerly wind events during winter (Santos, *et al.*, 2001; Borges *et al.*, 2003).

The exchange of water masses through the Gibraltar Straits is driven by the deep highly saline (S>37) and warm Mediterranean Outflow Water (MOW) that flows into the Gulf of Cadiz and the less saline, cool water mass of the Atlantic Intermediate Water (AIW) at the surface.

NAO is responsible for generating large amplitude patterns in windspeed anomalies and modifications in the direction of the wind during winter (Cayan, 1992). An increase in NAO index reflects a corresponding change in the strength of the winds across the Atlantic.

4.1.2 Seawater temperature

There is not available an updated series of SST for this year report.

Figure 4.4 presents information on SST for west Portugal from 1960 to 2004. An increasing trend is apparent since late 1970s.

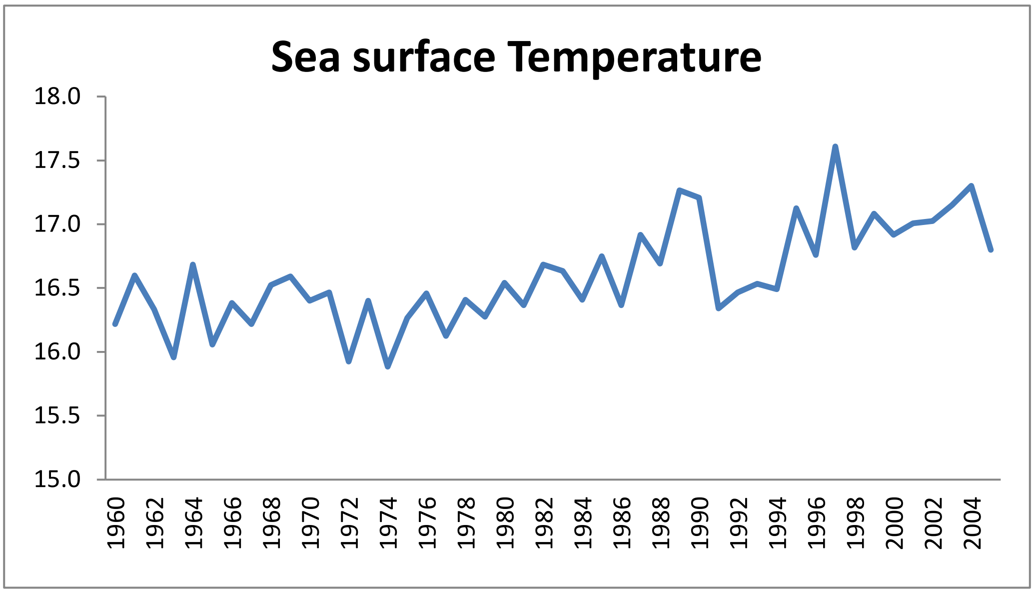

Figure 4.4. Mean sea surface temperature from ICOADS (reanalysis 2ºx2º grid data). Portugal (39.5ºN,9.5ºW). Unit Cº. (Courtesy of A.M. Santos, IPMA).

Relvas (2009) estimated SST data time-series (1960-2005) at different Portuguese geographic areas, figures 2.5 and 2.6 and estimated its trends. The results indicate generalized warming of a few hundredth of degree a year, ranging from 0.015°C/year to 0.037°C/year for the period starting in 1960, or from 0.022°C/year to 0.033°C/year if the time-series start in 1985.

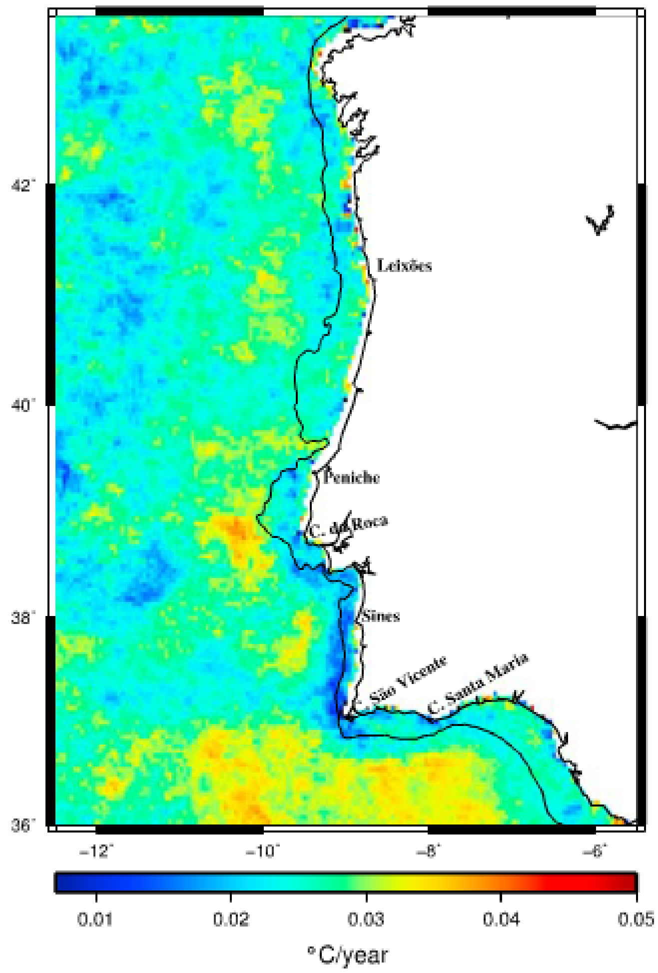

Figure 4.5. Mapping of SST anomalies from 1985-2005 during summer.

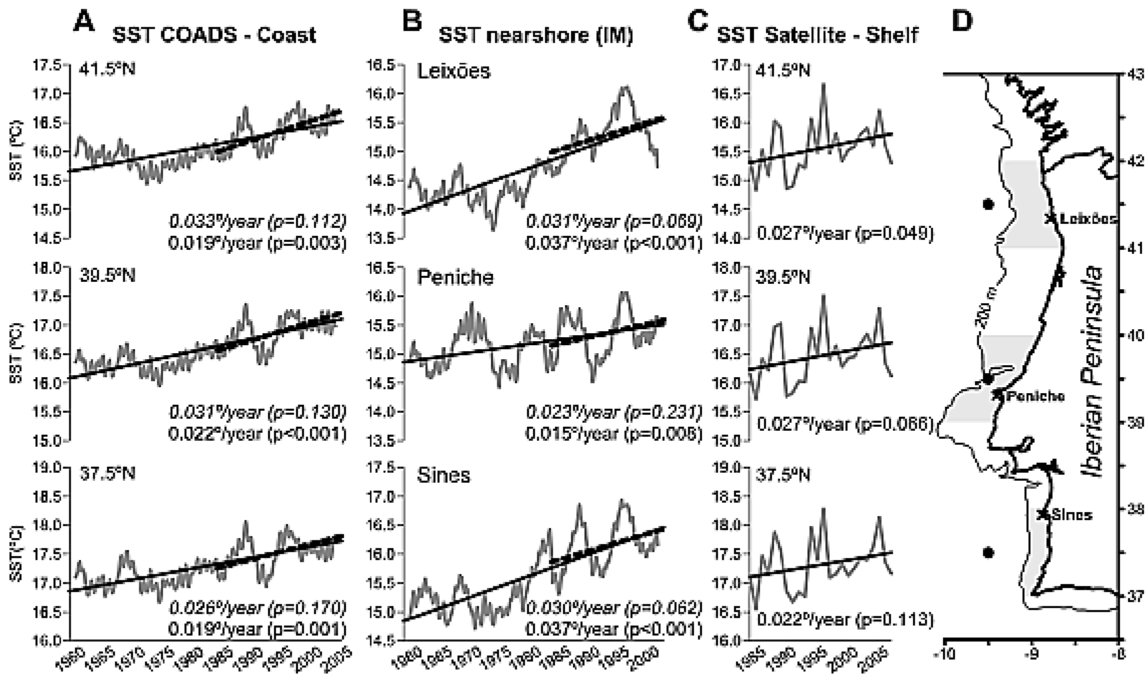

Figure 4.6 (a). Monthly mean SST time-series from ICOADS data for the period 1960–2005. Data correspond to gridded cells of 1° × 1°, whose central points are 9.5°W of longitude and, top to bottom, 41.5°N, 39.5°N, 37.5°N of latitude. Running means spanning 25 months are displayed (grey lines), along with linear fits for the whole time-series (solid lines) and for the 1985–2005 period (dashed lines). (b) Monthly mean SST measured directly from the seashore at three sites on the Portuguese coast, for the period 1960–2003. Top to bottom: Leixões (41.3°N), Peniche (39.3°N) and Sines (37.9°N). Running means spanning 25 months are displayed (grey lines), along with linear fits for the whole time-series (solid lines) and for the 1985–2003 period (dashed lines). (c) Monthly mean satellite AVHRR SST for the period 1985–2008 and corresponding linear fits, averaged zonally from the coast offshore till the 200 meters isobath and meridionally at 1° latitude, centred on three latitudes along the west coast, top to bottom, 41.5°N, 39.5°N and 37.5°N (grey lines). (d) Map of the Western Iberia coast, showing the location of the central points of the 1° × 1° ICOADS cells (dots) and the coastal sites: Leixões, Peniche, and Sines (crosses). The 200 meters isobath is shown. Grey shading represents the regions where the satellite AVHRR SST was spatially averaged. Numerical values of the trends are indicated along with the corresponding p-values (italic for the shorter time-series). (adapted from Relvas , 2009)

SST anomalies for the period 1960-2005 in the area are locally differentiated and in the shelf show a small increase in the range 0.01-003 as indicated in Figure 4.5. Anomaly is increasing and higher towards the open sea. During summer upwelling events mix the water column closer to the shelf and therefore the SST decreases. At open sea closer to the Azores High the SST increase anomaly is evident (Figure 4.5). The SST increase effect on species populations (e.g recruitment success, migrations changes) is therefore expected to be responding to spatial localized climate events (Brander, *et. al*, 2003).

4.2 Biotic processes

4.2.1 Primary production

Most important features enhancing primary production are coastal upwelling, coastal run-off and river plumes, seasonal currents and internal waves and tidal fronts. Upwelled waters are usually advected offshore forming filaments that extend westward following the 200m isobaths and transporting biological material towards oceanic waters. The main patterns of phytoplankton biomass are related to water column stratification, nutrient availability and the intensity and persistence of upwelling conditions. Maximum values of chlorophyll usually occur in spring and summer (Nogueira *et al*., 1997; Moita, 2001), although high chlorophyll values may also be recorded in autumn, particularly in zones with elevated retention characteristics; for example, high chlorophyll concentrations are found in the Rías Baixas, at the time of the seasonal transition from upwelling to downwelling (Nogueira *et al*., 1997; Figueiras *et al*., 2002). In summer, a recurrent band of high chlorophyll concentration is found near the coast and associated with upwelled waters and strong cross-shelf gradients that separate upwelled and oceanic waters. Maximum values of chlorophyll near the coast occur in surface waters, while offshore these maxima extend subsurface and coincide with the nutricline (Moita, 2001; Tilstone *et al*., 2003). Pulses of weak-to-moderate upwelling disrupt stratification and bring nutrients into the photic zone allowing phytoplankton growth on the inshore side of a well-developed thermal front, while stratified oceanic waters offshore of the front remain poor in phytoplankton owing to nutrient depletion (Moita, 2001).

The onset of the spring bloom occurs sometimes as soon as February in western Iberia and the south of the advisory region (Nogueira *et al.,* 1997). By March-early April the spring bloom covers the entire offshore region. The autumn bloom is variable, and restricted to coastal areas, for example, high chlorophyll concentrations are found in the Rías Baixas, at the time of seasonal transition from upwelling to downwelling (Nogueira *et al.,* 1997; Figueiras *et al.,* 2002). During winter and in the coastal areas inwards the 100 m isobath chlorophyll estimates persist relatively high.

Filaments and fronts associated with high salinity water of subtropical origin (Eastern North Atlantic Water, also known as the 'Navidad' Current) are important along the Iberian margin. During winter and spring, the Navidad Current results in a convergent front at the boundary between coastal and oceanic water. When saline intrusion is weak, the development of fronts and the formation of a seasonal thermocline are enhanced, leading to phytoplankton blooms. When saline intrusion is intense, strong vertical mixing occurs and prevents phytoplankton growth in spring (Moita, 2001; Santos *et al*., 2004).

In Portugal, seasonal differences in river discharge can give rise to both river plumes and to lenses of lower salinity. These lenses are particularly rich in phytoplankton and are characterized by the near absence of coccolithophorid species during summer between the Minho and Douro rivers. Along the Portuguese coast coccolithophorids act as tracers for this current. Upwelling of North Atlantic Central Water and even Eastern North Atlantic Water is a common feature along the Portuguese and Galician coasts and in the western Cantabrian Sea,

Toxic dinoflagellates and diatoms are regular components of the marine phytoplankton community and can render shellfish toxic at concentrations as low as 102-103cells/l, well below those causing water coloration (i.e. > 106cells/l). Their maximum concentrations exhibit interannual variations determined mainly by changes in the upwelling regime, river run-off, inoculum size and other environmental parameters. Cape Finisterre constitutes a biogeographic boundary for the proliferation of toxic species, such as *Gymnodinium catenatum, Dinophysis acuta* and *D. acuminate* (Figure 4.7).

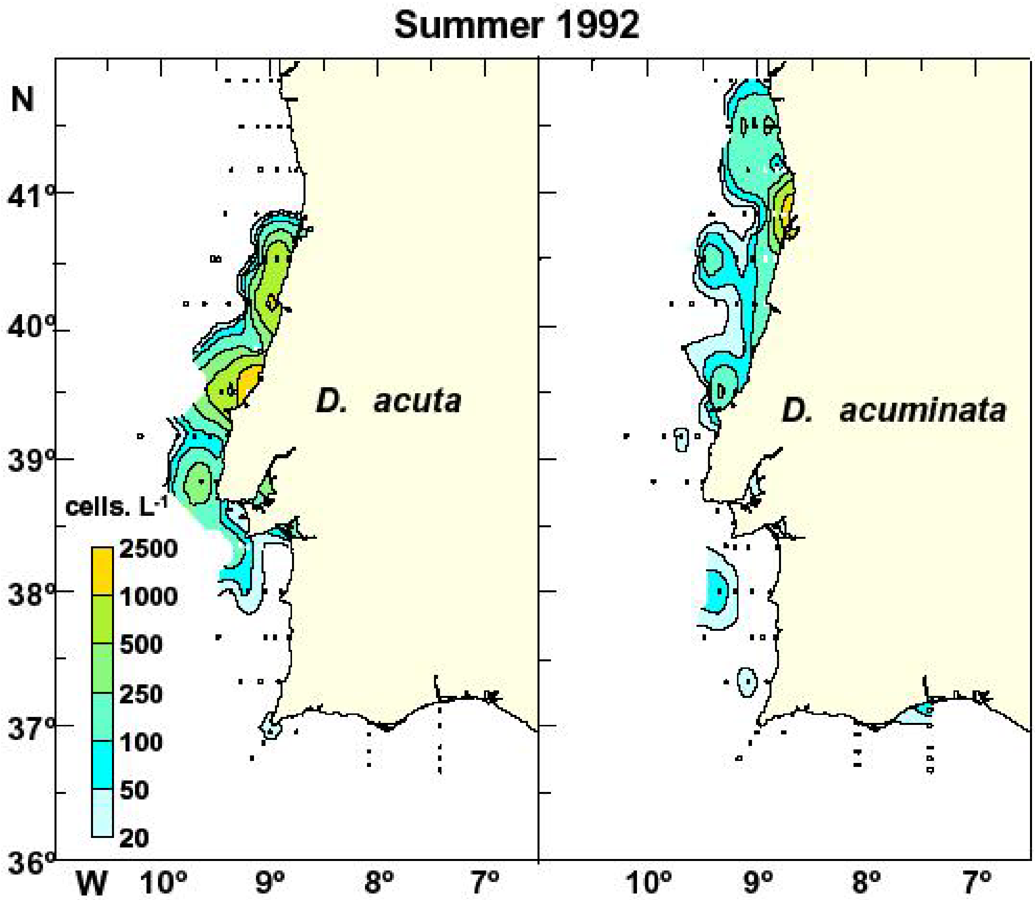

Figure 4.7. Distribution of *D. acuta* and *D. acuminata* during summer of 1992 on the Western Iberian coast of Portugal (source: GEOHAB 2005).

The mixotrophic species *Dinophysis acuminata* and *D. acuta* are most abundant at the end of spring and during summer or in well-stratified water columns in upwelling shadows, where they are able to benefit from regeneration processes and food availability (Ríos *et al.*, 1995). Despite their preference for stratified waters, these species bloom inshore of the upwelling front during summer and may at times be the only dinoflagellate representatives within chain-forming diatom assemblages (Moita, 2001). *Dinophysis* species have the greatest economic impact on shellfish harvests owing to their persistence in the Iberian system for much of the year, albeit in very moderate numbers (102–103 cells·l-1). *D. acuminata* and *D. acuta* often coexist but maximum concentrations do not coincide in space or in time. *D. acuminata* maxima are typically found in the north of of Portugal and in Galician Rias associated with lower temperatures and salinities, whereas *D. acuta* concentrations are typically higher towards the south (Reguera *et al.,* 1993; Palma *et al.,* 1998). When both species bloom along the west coast of Iberia, the highest concentrations of *D. acuminata* typically occur to the north of *D. acuta* ocurrence. As summer progresses blooms of *D. acuta* can be displaced northward, reaching the Galician Rias. *D. acuta* on the Iberian coast therefore shows a marked seasonal presence occurring first on the Portuguese coast with autumn peaks to the north associated with the autumn upwelling-downwelling transition (Reguera *et al.,* 1995; Sordo *et al.,* 2001).

4.2.2 Zooplankton

Mesozooplankton information is available for the period 2005-2011 from sampling obtained using Continuos Underway Fish Egg Sampling (CUFES during routine Portuguese acoustic surveys. Figure 4.8 indicate the sampling areas and the density.

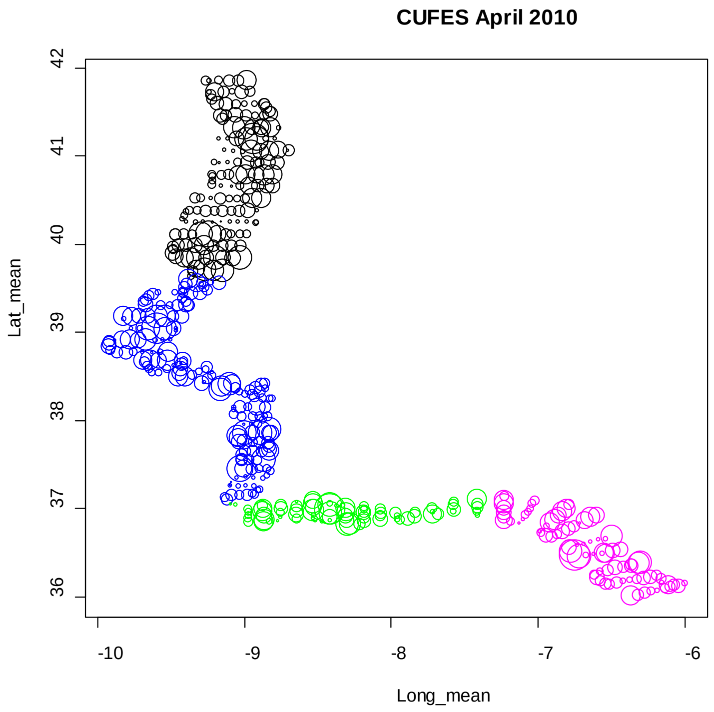

Figure 4.8. Density of mesozooplankton (ml/m^3, CUFES, malha 335 μm) sampled during sardine acoustic survey 2010. (courtesy of M. Angélico, IPMA; MSFD, 2012)

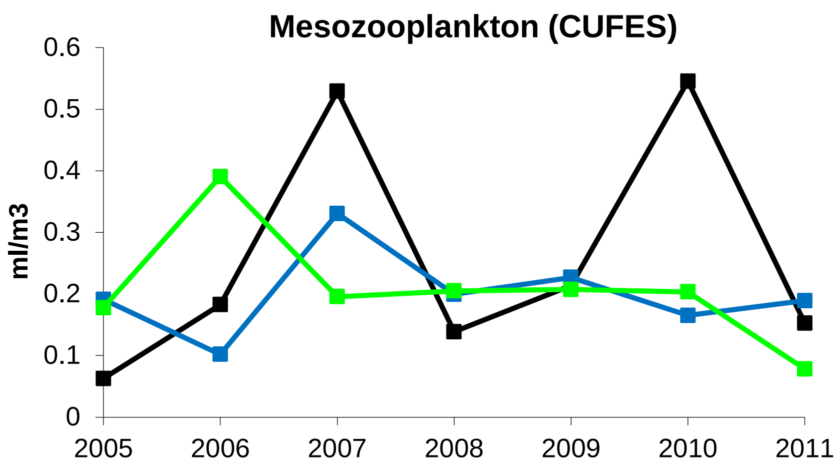

Figure 4.9. Mean abundance of Mesozooplankton volume (ml/m^3) by geographical area. (courtesy of M. Angélico, IPMA; MSFD, 2012)

4.2.3 Fish Recruitment

Climate impacts

Dickson *et al.,* (1988) showed how the increased northerly winds during the 1970s were coupled with increased upwelling off Portugal, a decline in zooplankton and phytoplankton in the North Atlantic and declines in the catch of sardines off Portugal. During early 1990s extreme positive NAO anomalies were observed and these were associated to increased frequency of winter wind leading to changes in the upwelling seasonal patterns off Portugal which adversely affected recruitment of sardine and horse mackerel (Borges *et al.*, 1997; Santos *et al.*, 2001). The upwelling events observed off Portugal during winter, which correspond in the region to the spawning season for sardine and horse mackerel and most other species, had negative impact on the recruitment of these fish species. This effect on recruitment seem to be due to an increase in conditions favorable to the offshore transport of larvae and consequently an increase in their mortality (Santos *et al.*, 2001). Later a negative relationship between the intensity of northern winds in Winter and upwelled water increasing offshore transport and sardine landings off Portugal and Galicia South have been demonstrated (Borges *et al.*, 2003; Guisande *et al.*, 2004).

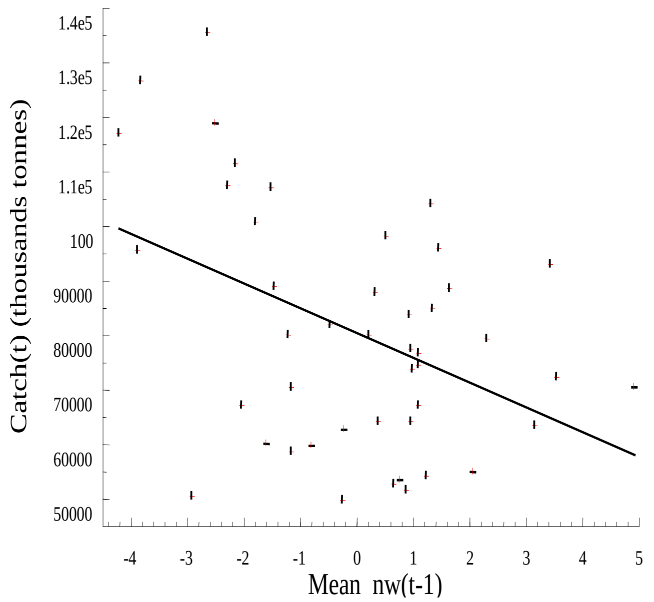

Figure 4.10. Sardine catches (1946-1999) vs. north wind-mean (Mean_nw) index one year before. (statistically significant (p= 0.0036). A positive Mean_nw value means that the wind direction is from the north (northerly wind) and a negative value means that the wind blows from south (southerlies) in the west coast of Portugal. (From Borges, *et al.*, 2003).

Periods of high and low sardine (*Sardina pilchardus*) recruitment have been observed to occur independently of spawning-stock biomass level. Sardine production ratio (R/SSB) was observed to be higher when Winter NAO was negative and lower when Winter NAO presented negative values, with a time-lag of three years (Borges, *et al.*, 2012).

Identical dynamics was found to occur for other species in the region as for Southern Hake (Merluccius *merluccius*) and Norway lobster (*Nephrops norvegicus*) production ratios, which respond inversely to Winter NAO index with the time-lag of 3 years. The significance of the association increases with the inclusion of Eastern Atlantic Pattern (EA) index which is a proxy of SST (Borges,*et al.*, 2008).

4.3 Human impacts

Based on a review of the national reports to the MSFD and OSPAR documents, the major impacts by humans in Region IV marine ecosystem are from fisheries, tourism, aggregate extraction, non –indigenous species introduction and shipping. Other than fishing, it is assumed that the impact of all the other activities will either stay the same or increase in the future.

These activities cause multiple pressures, some of which are considered cumulative in effect. The impact appears to be greatest in terms on the selective removable of biomass, changes to the marine habitat through destruction or adaptation and the addition of new substances into the system.

4.3.1 Fishing impact on seabed

Figure 4.11 describes the sediment type of part of the subregion (Source: MSFD, Portugal, 2012).

The areas of bottom-trawl fishing activity in this subdivision are delineated in Figures 4.12, and 4.13 based on VMS information from 2005 as presented in Borges et al., 2010, FP7 MEFEPO project and in the MSFD Initial Assessment Report, 2012 Portugal.

In Figure 4.12 grey areas correspond to the most intensely trawled areas as indicated by VMS analysis. Nevertheless because the shelf is narrow and many areas are not suitable for bottom trawling the impact measured as the proportion of area impacted by mobile bottom gears (bottom trawl) relatively to the EEZ area is low.

An analysis performed by depth band have shown that in the depth band of 0-20 m depth 98% of the area is not trawled. Further than 200 meters depth 99% of the area is also not trawled. The most affected are intermediate depth bands from 20-80m depth which are trawled about 50% and 80-200m depth where only 36% of the area is not trawled. (Borges, *et al*. 2010)

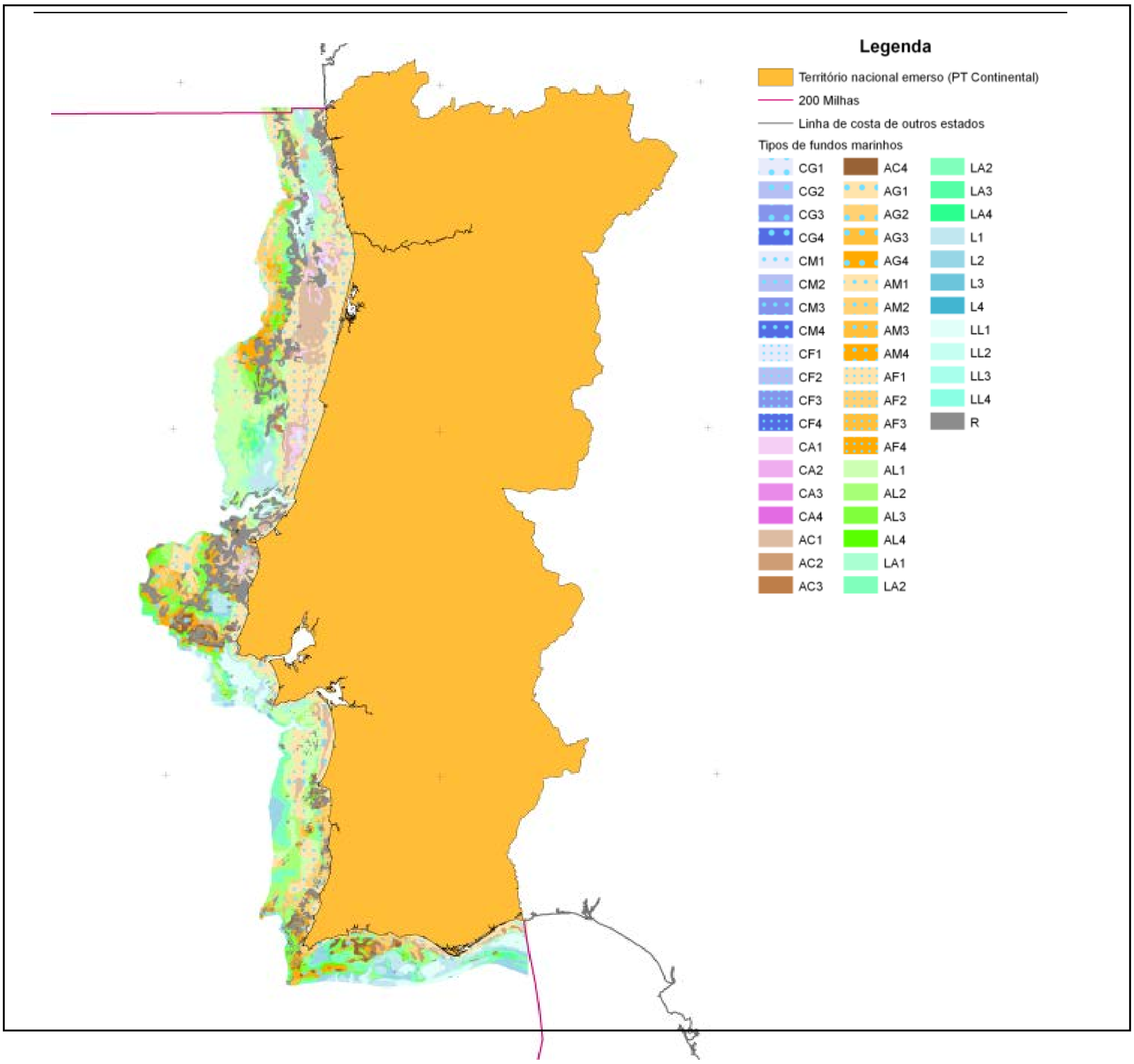

Figure 4.11. Sediment type (Source MSFD, Portugal, 2012)

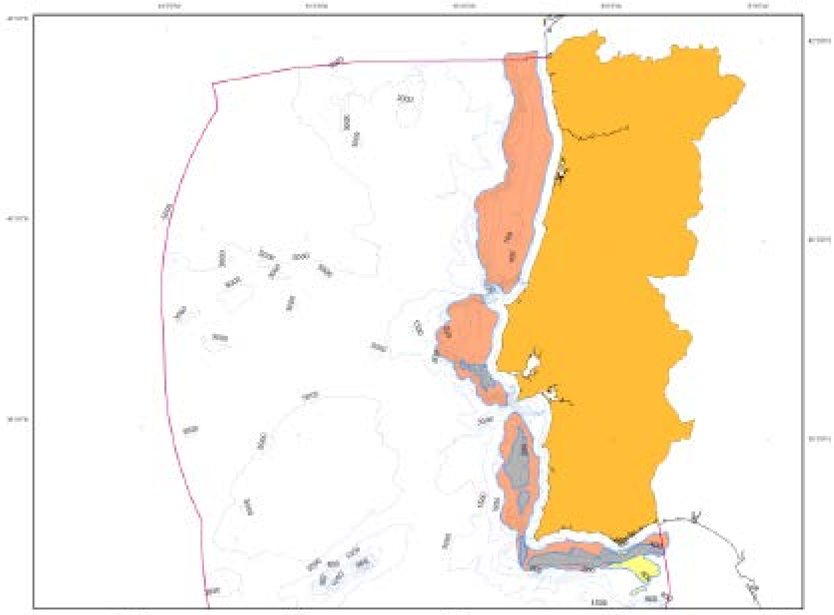

Figure 4.12. Mapping of bottom trawling based on VMS. (MSFD, Portugal, 2012). Pink areas correspond to trawling directed to fish and yellow areas to crustaceans. Grey areas are the overlapping of both type of trawl fishing activity. Pink line is the EEZ delimitation.

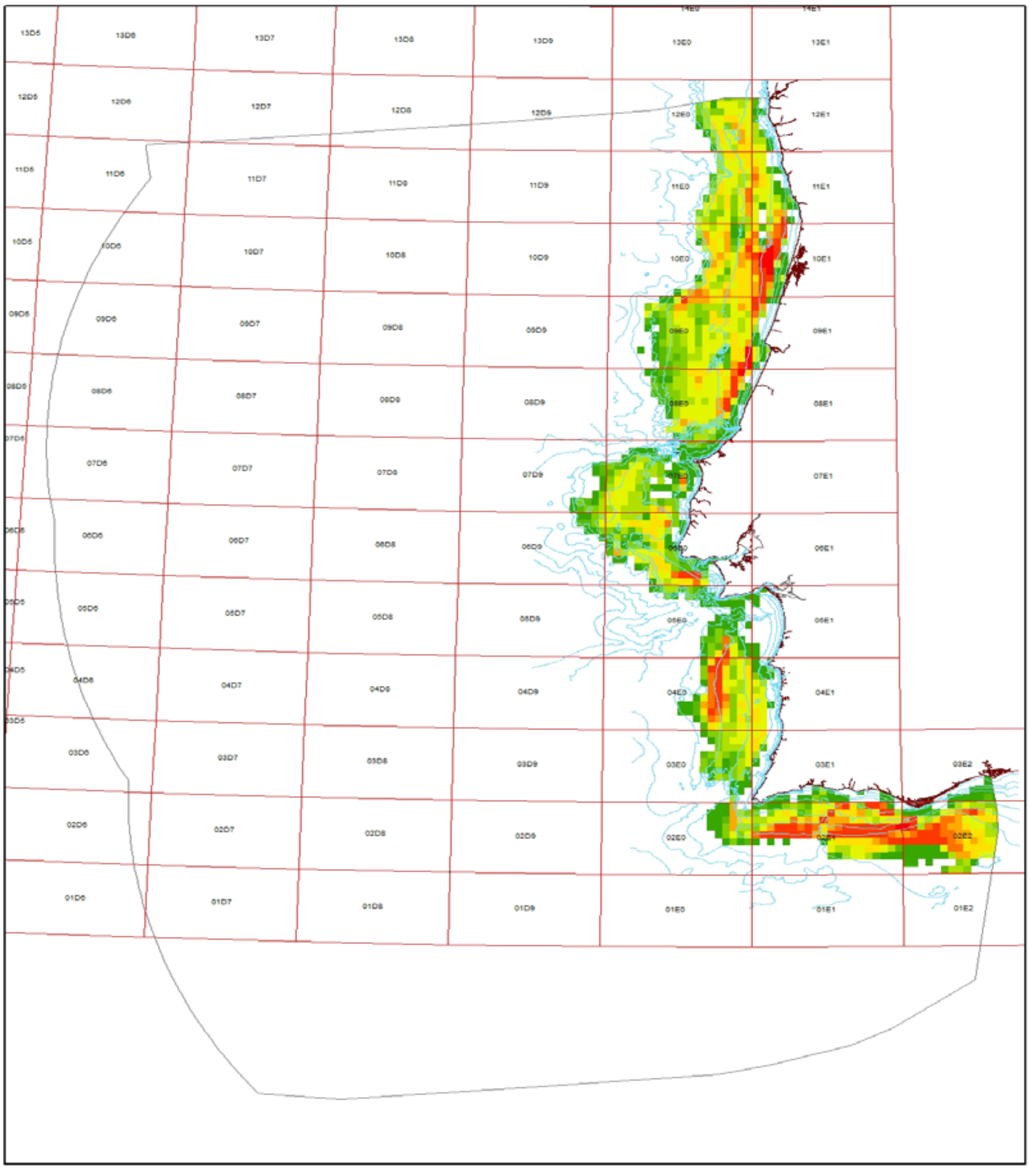

Figure 4.13. example fishing activity plot based on VMS data. Calculated based on 2005 VMS data from submitting nations. From Borges et al 2010 MEFEPO Southwestern Waters GES report. See Borges et al 2010 for description of methods. [Borges et al. 2010Assessing the impact of fishing on the Marine Strategy Framework Directive objectives for Good Environmental Status. MEFEPO FP7 project WP2 report. www.liv.ac.uk/mefepo/.]

4.3.2 Gas and oil

Figure 4.14 indicates oceanic areas of prospection of oil and gas in part of the subdivision, as presented in MSFD, Portuguese Initial Assessment report, 2012.

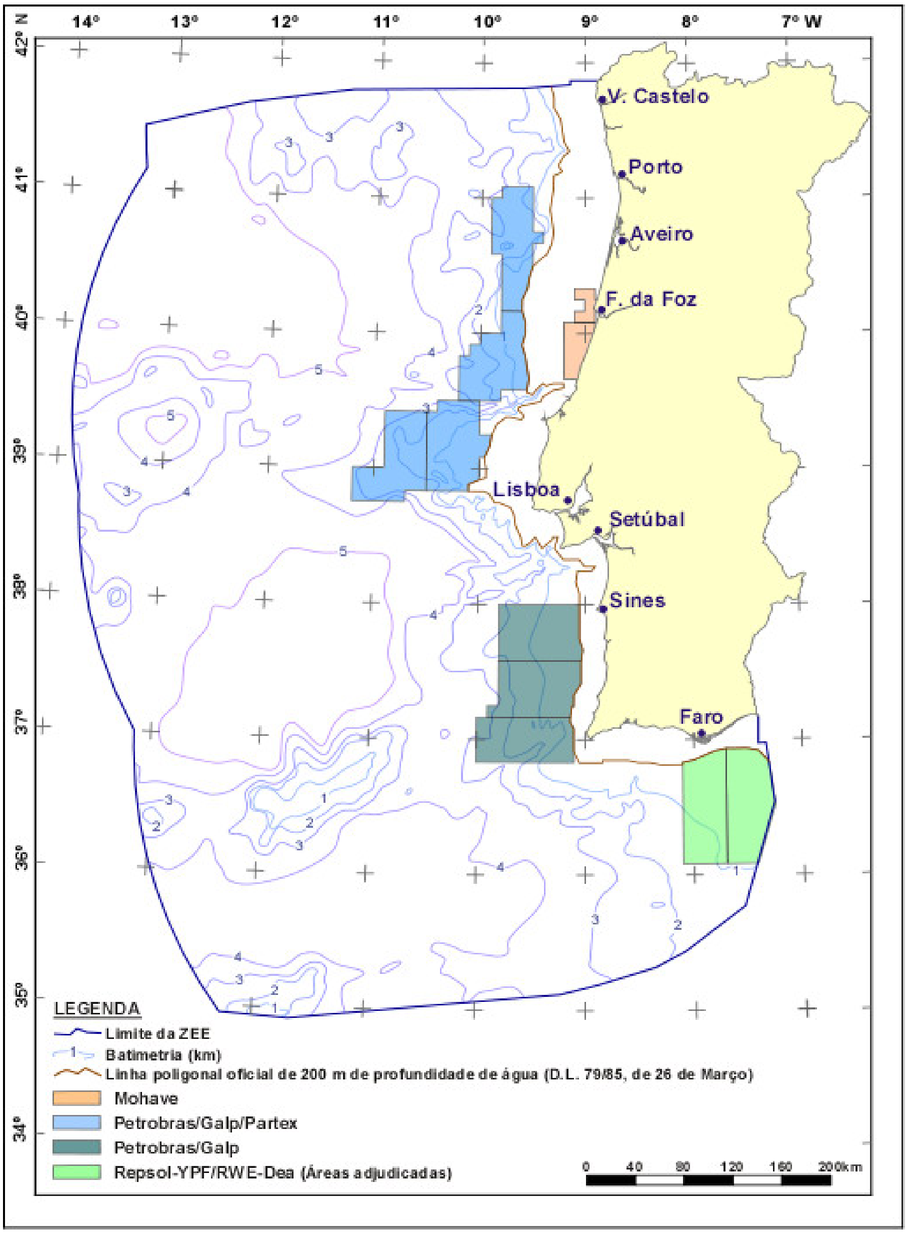

Figure 4.14. Oil and Gas Prospection areas. (Source: MSFD Portugal, 2012).

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5 Gulf of Cadiz subregion

5.1 Key signals

5.1.1 Physical and chemical oceanography

Temperature and salinity trends

Sea surface temperature in the GoC is characterized by a strong seasonal cycle, typical of temperate seas. Beyond this regular pattern, and as most Western European Shelf Seas, the Gulf of Cadiz is currently warming at a 0.5 ºC per decade (Figure 5.1). Similarly, salinity records show a positive trend over the last decades.

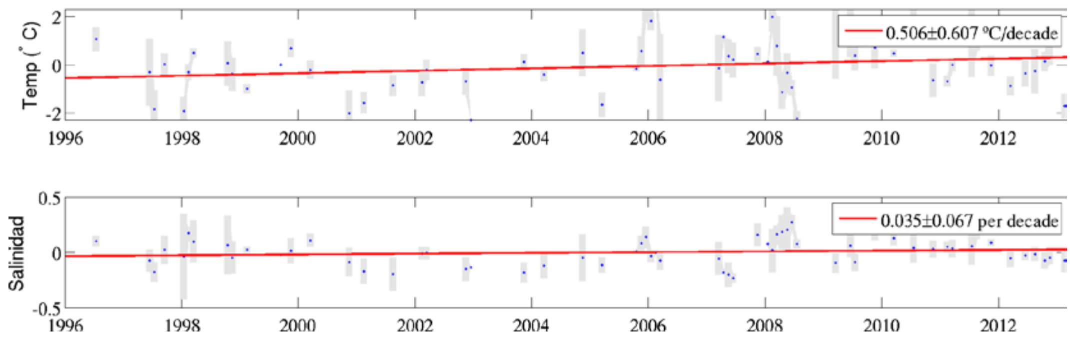

Figure 5.1. Sea surface temperature and salinity trends (10 m) in the Gulf of Cadiz, local measures from CTD (Sánchez et al. in prep.).

Three processes can disrupt the seasonal pattern and locally affect the trends described above and therefore are worth monitoring: (i) upwelling events, locally important towards the northern margin (Figure 5.2), (ii) the Mediterranean water, which spills over into the Atlantic through the Strait of Gibraltar at a depth of 800-1200 m (Figure 5.3), and (iii) the Guadalquivir discharges, with obvious implications beyond the temperature and salinity signal (Figure 5.4).

i) the coastal upwelling is driven by westerlies and are important in the region stretching from Cape Santa Maria to the Guadalquivir mouth (Prieto et al. 2009). Figure 5.2 shows the effect on the sea surface temperature of an episode of winds from the west compared to opposite conditions (levanters) some days later.

ii) the effects of the Mediterranean Water, and the associated entrainment and mixing processes, is less known but it may well have an effect, particularly on the demersal component.

iii) The Guadalquivir estuary is known to be used as a nursery area for a number of species (Baldó and Drake 2002, Drake et al. 2007). The discharges from the Guadalquivir are to a great extent dependent on the regulation of the Alacalá dam (110 km upstream) and hence it constitutes a driver that can be directly manageable (Drake et al. 2002).

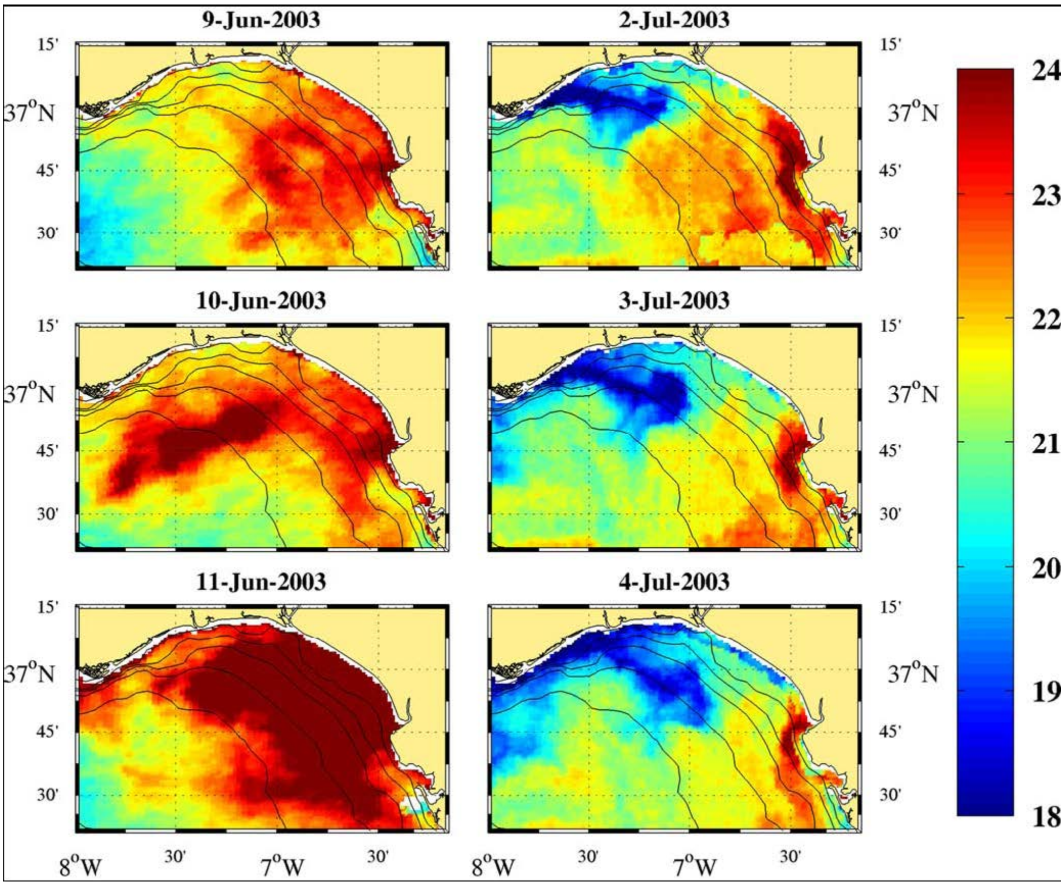

Figure 5.2. SST images from AVHRR-NOAA showing dowelling (left) and upwelling (right) events. June 9, 10 and 11th of 2003 during intense easterly winds (left columns), and July 2, 3 and 4th of 2003 during westerly winds (right columns). Source: Prieto et al. (2009).

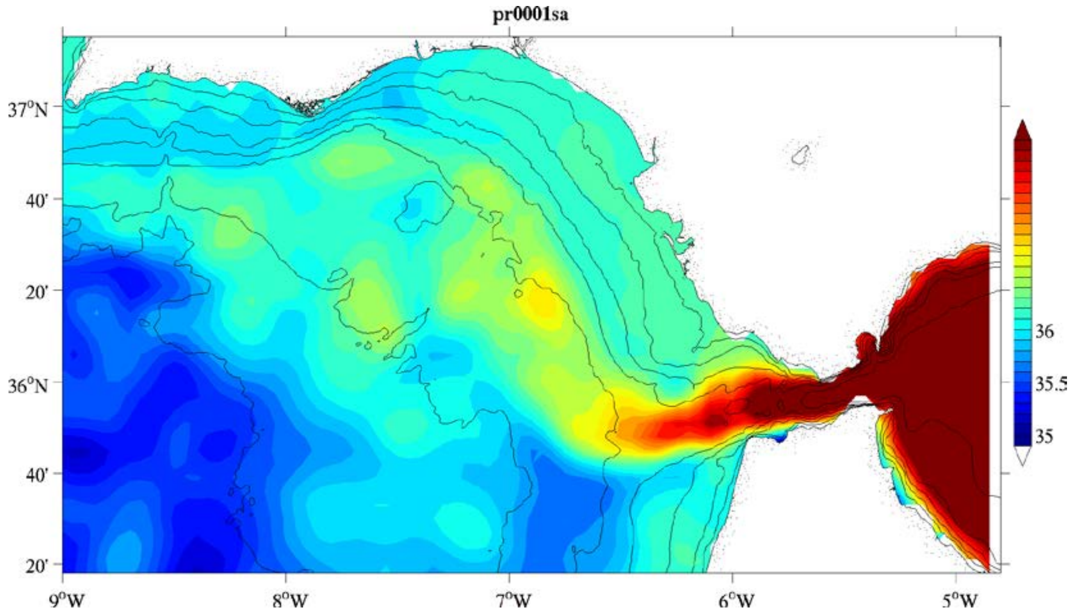

Figure 5.3. Bottom salinity field showing the Mediterranean water flow into the GoC. Source: SEADATANET.

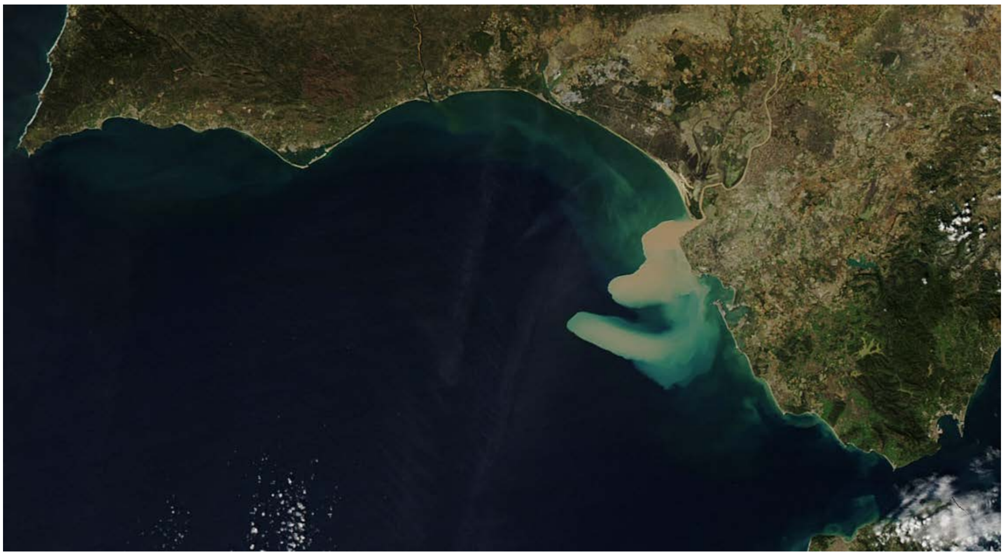

Figure 5.4. Guadalquivir discharge event in November 2012. Source: NASA.

Circulation

The processes mentioned above (river discharges, upwelling) together with the general circulation (North Atlantic subtropical gyres), local topography and wind regime conspire to generate a surface pattern consisting of two main coastal cells (Figure 5.5). This general circulation has implications on the productivity of the system and it is known to affect the recruitment of commercially important species, such as anchovy (Navarro and Ruiz 2006, García-Lafuente and Ruiz 2007, Ruiz et al. 2009).

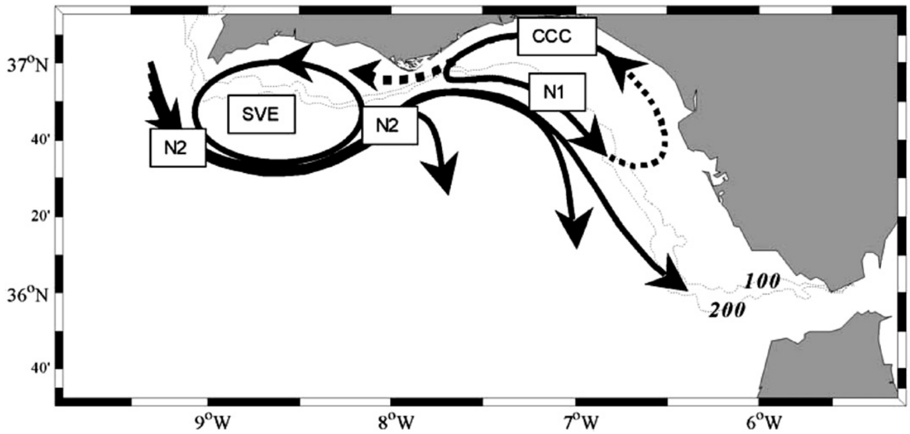

Figure 5.5 Schematic circulation features (summer) in the Gulf of Cádiz. N1 and N2 stand for eastward circulation currents whereas CCC and SVE for a coastal countercurrent and a cyclonic gyre. From García-Lafuente and Ruiz (2007).

5.2 Biotic processes

5.2.1 Gulf of Cadiz

Production

Despite the GoC waters being generally considered as oligotrophic, the existence of local upwellings and deep nutrient-rich waters, make the ecosystem sustain an important biological and fishing activity.

Phytoplankton

The GoC is probably the least known region of the European Western Waters when it comes to plankton. It lacks consistent time-series of phytoplankton. Apart from a few isolated studies on general groups (Prieto et al. 1999), most of the information comes from indirect studies based on satellite colour. Navarro and Ruiz (2006) describe 5 zones which roughly correspond to the hydrographical features mentioned above (Figure 5.6). It's recommended to incorporate phytoplankton to the existing monitoring programmes in order to generate information on the structure and changes of this component and be able to report possible trends.

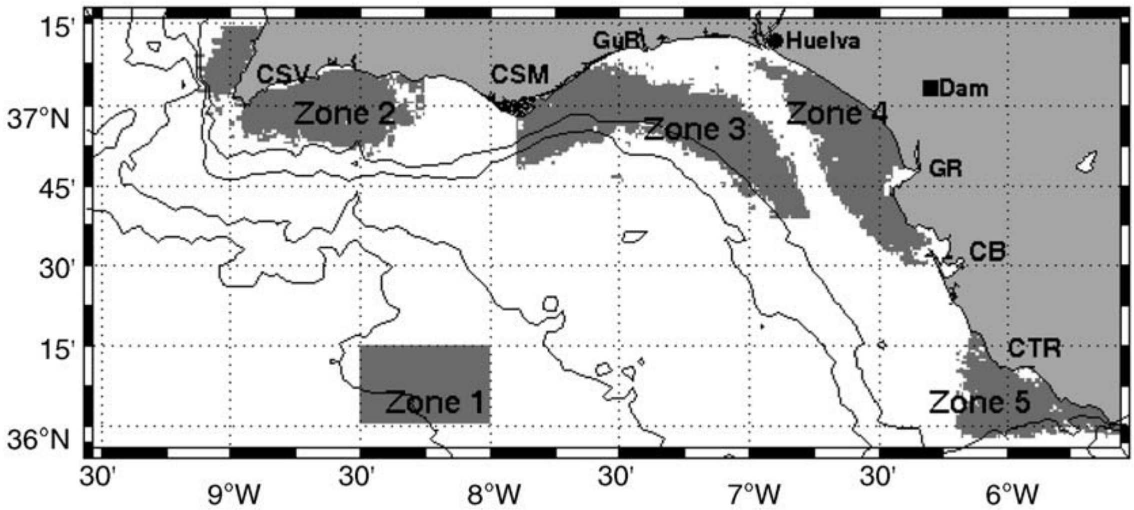

Figure 5.6. Regionalization based on EOF analysis of colour satellite imaginery. Zone 1 (open ocean), Zone 2 (Cape San Vicente), Zone 3 (Cape Santa María), Zone 4 (coastal zone between Guadiana and Guadalquivir river mouths), and Zone 5 (Cape Trafalgar), Navarro and Ruiz (2006).

Zooplankton

Similarly to phytoplankton, to date there is no readily available historical information on this component apart from a few isolated studies (e.g.. Mafalda et al. 2007). However, there is a considerable number of samples covering the whole area and spanning over a period of several years with (at least) seasonal resolution. Recently, the IEO has started to analyse these samples that were archived due to lack of expertise on zooplankton identification. Preliminary results have provided information about the main species that make up the community off the Guadalquivir mouth (Figure 5.7). In the future we expect to be able to describe their temporal and spatial variability.

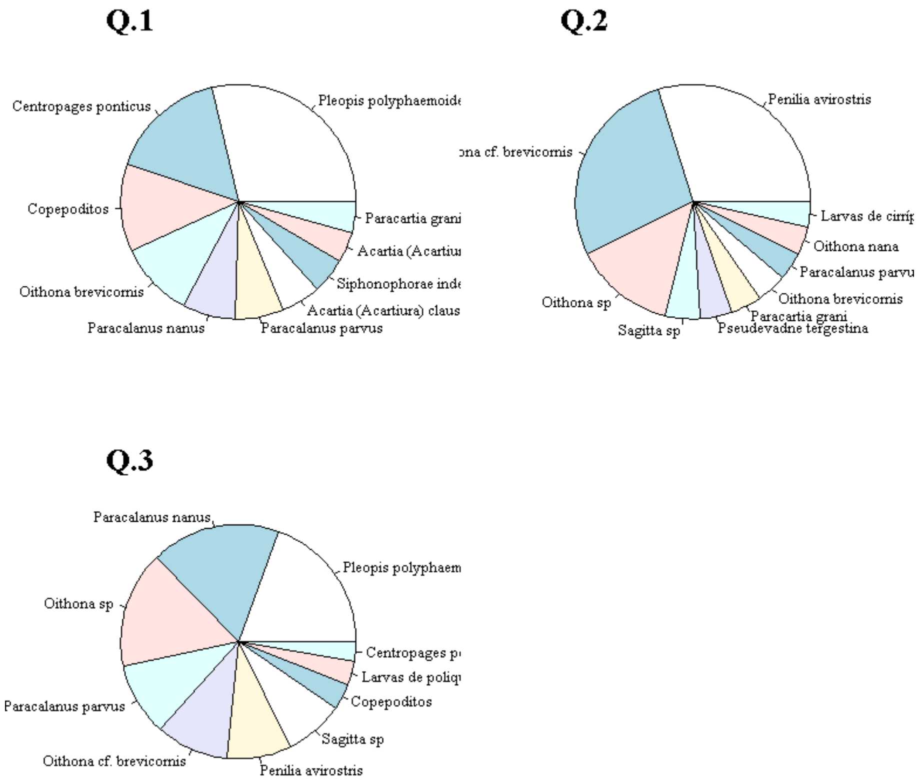

Figure 5.7. Main zooplankton species per year quarter at a station located off the Guadalquivir mouth. Source: IEO.

Fish

The demersal resources are by far the best studied component of the GoC ecosystem. Bottom-trawl surveys (ARSA) have been carried out in the area since 1993. This database constitutes the longest biological time-series in the area. A preliminary traffic light analysis shows the evolution of the main functional groups over the last 18 years (Figure 5.8).

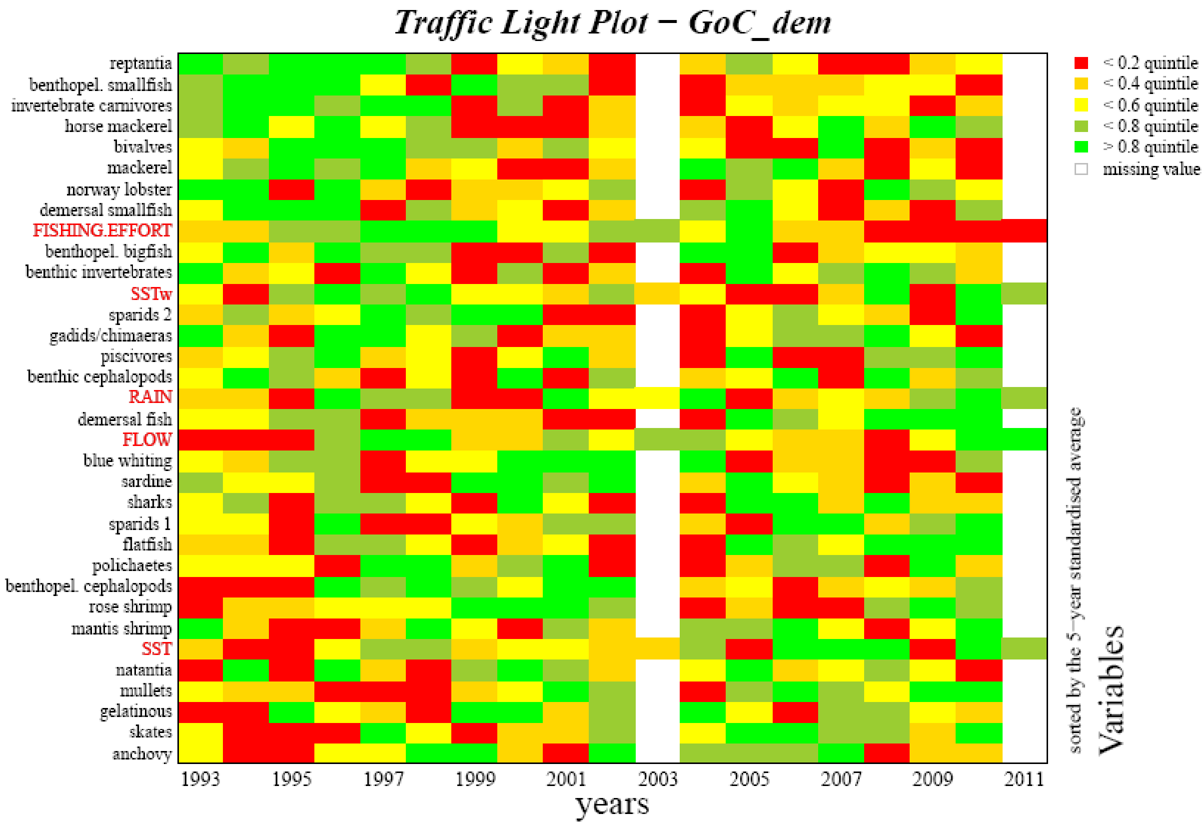

Figure 5.8. Traffic-light plot representing the development of the GoC demersal ecosystem over the last couple of decades. Trophic levels/functional groups are labelled in black whereas environmental variables and fishing effort are in red. Time-series were transformed into quintiles and sorted according to PC1; red represents high values while green represents low values of the respective variable. Source: IEO.

5.3 Human impacts

5.3.1 Activity

Extraction of aggregates

The Costa de la Luz is a relatively important touristic destination and the quality of its beaches one of its major draws. Beach restoration is a priority and dredging an important activity. Figure 5.9 shows the annual evolution of sand extraction from the seabed.

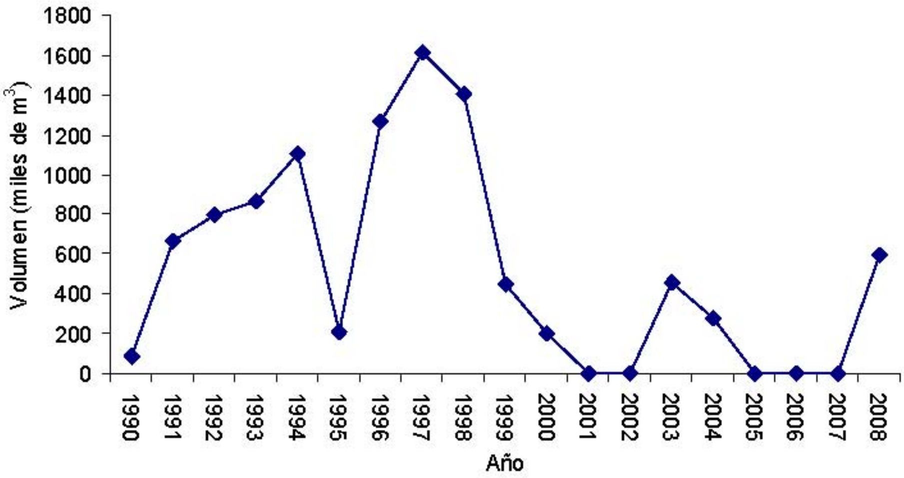

Figure 5.9. Annual volume of sand extracted from the seabed for beach nourishment. Source: OSPAR.

Dam regulation

As put forward above, the estuaries of the Guadalquivir and other rivers are key areas for the GoC ecosystem and are affected by upstream dam management. Figure 5.10 shows the increase in storage capacity per catchment area from the mid 1990s, which affects the amount of water that flows into the estuaries, and reflects the potential effect of this activity.

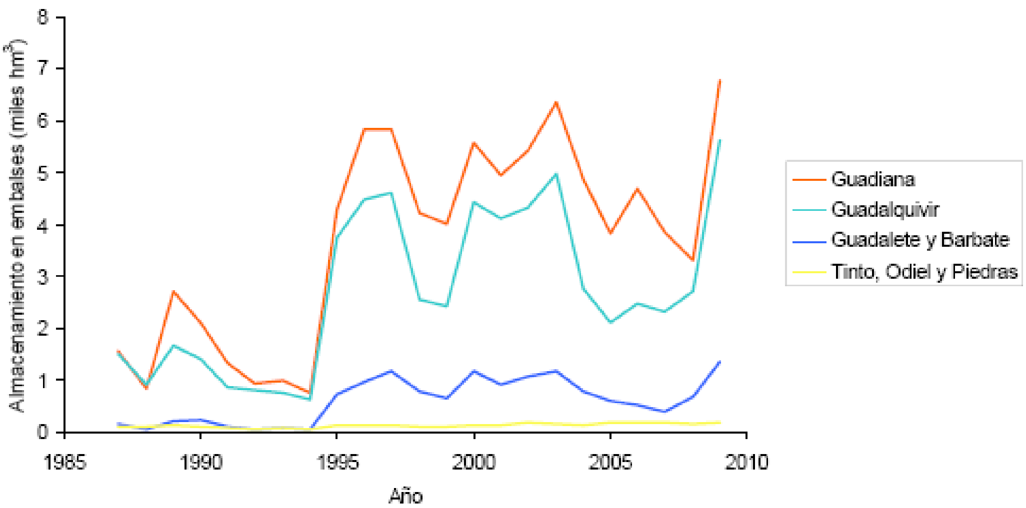

Figure 5.10. volume of water (hm3) per catchment area. Source: OSPAR.

Fisheries

Demersal trawl and purse-seine fishing activity mapped using VMS data. The figure shows that the whole area is strongly impacted by one or the other, with the northern margin standing out as a hot spot where both activities overlap.

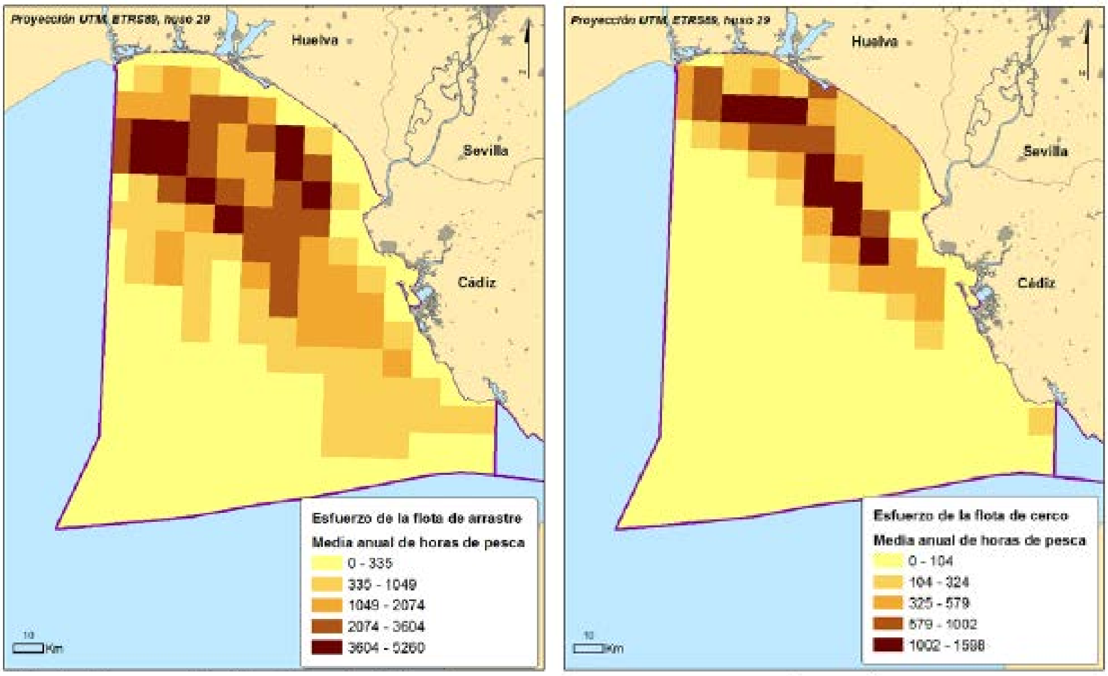

Figure 5.10. Fishing effort, bottom trawl (left) and purse-seine (right), from VMS. Source: OSPAR.

The number of fished days shows a decline in the last years (Figure 5.11).

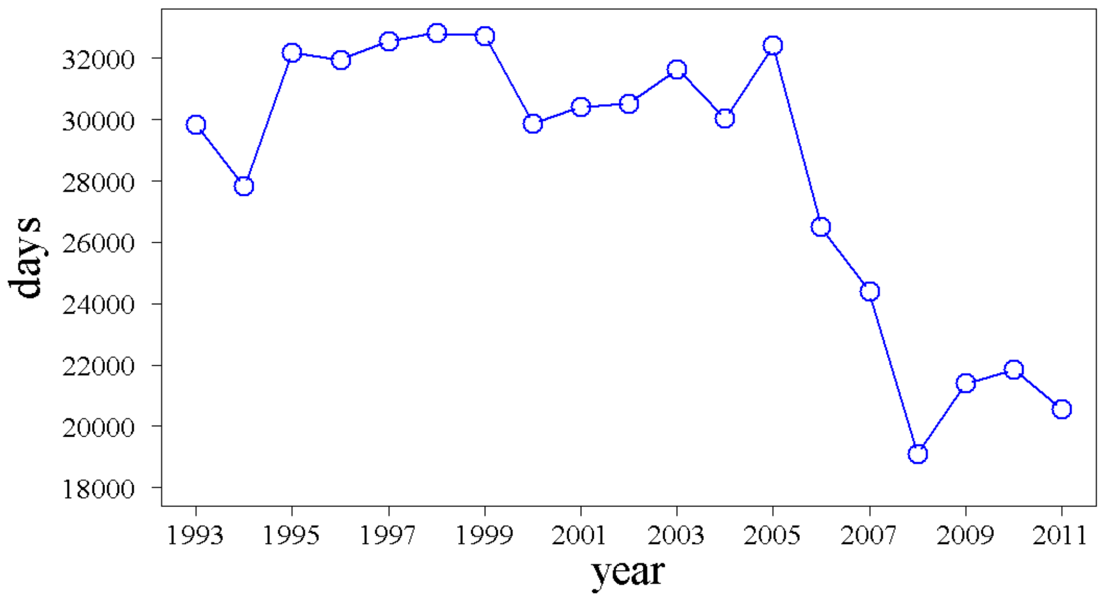

Figure 5.10. Days fished bottom-trawl fishing activity per year. Source: IEO.

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Ruiz J R, González-Quirós R, Prieto L, Navarro G (2009) A Bayesian model for anchovy (*Engraulis encrasicolus*): the combined forcing of man and environment. Fish. Oceanogr. 18(1): 62–76.

Annex 7: ICES Celtic Sea Ecosystem Overview

1 Description of the Ecoregion

1.1 Ecoregion boundaries and geography

The Celtic Seas ecoregion has been recently delineated in a number of ways (Figure 1-3). The ICES ecoregion, the OSPAR region III and the new MSFD ecoregion all differ slightly. The main difference is that the OSPAR region is restricted to the shelf, while the ICES and MSFD ecoregions extend further off shore. For the purpose of the overview the Celtic Seas are considered to consist of five subregions, of which the Celtic Sea and Irish Sea have had extensive ecosystem descriptions prepared. The remainder lay outside the original scope of WGEAWESS

1) The Celtic Sea; Bounded to the east at the Ushant Front (48°38′N 4°34′W to 50°04′N 5°43′W). To the northeast by the Celtic Sea Front (51.9N, 5.32W to 52.2N, 6.35W). To the northwest, using the northern boundary of ICES Subarea VIIj 52° 30′N. And to the southwest along a line of 48°N. The western boundary was taken as the shelf break.

2) The Irish Sea – bounded by the Celtic Sea Front to the south and the Islay Front to the north

3) The West of Ireland – bounded by the shelf break, latitude 52° 30′N to the south and 54° 30′N to the north

4) West of Scotland – bounded by the shelf break, latitude 54° 30′N to the south and 60°N and the 4°W line to the east.

5) The Deep-water areas west of the shelf and out to the boundaries of the ecoregion.

Figure 1.1. ICES Celtic Seas Ecoregion and bathymetry (source ICES)

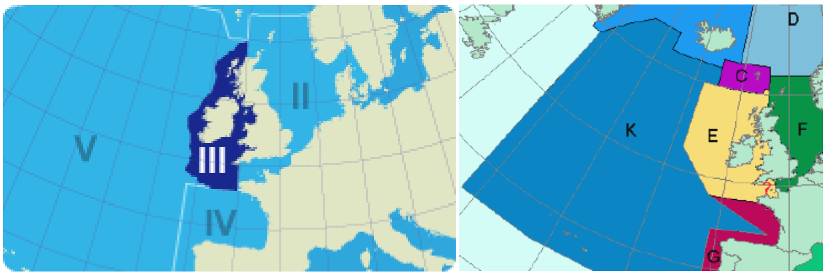


Figure 1.2. OSPAR Region III (left) and MSFD Celtic Seas Ecoregion (right)

1.1.1 Bathymetry

The Celtic Sea south of Ireland is an extended shelf within which most of the area is shallower than 100m. It is limited to the west by the slope of the Porcupine seabight and the Goban Spur. The shelf break is generally quite sharp except in the inner part of the Sea Bight. A general map of the Celtic Sea bathymetry is presented in figure 1.3.

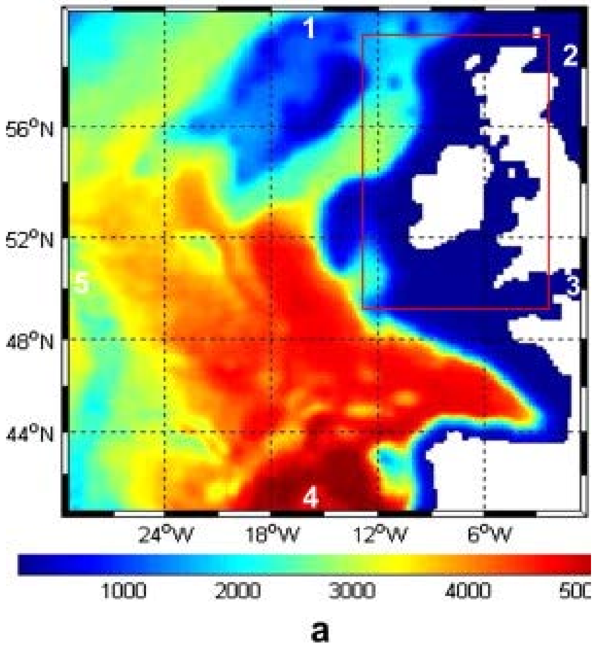


Figure 1.3. General bathymetric view of the Celtic Seas Ecoregion Olbert, A. I. and M. Hartnett (2010). "Storms and surges in Irish coastal waters." Ocean Modelling 34(1-2): 50-62

1.2 Ecoregion management

This ecoregion falls within the EEZs of Ireland, UK and France. This also means that the European Union has the competence for its management. The area als lies within the OSPAR management area as OSPAR Region III). In EU waters the management of fisheries includes the regional consultative body the Northwestern Waters Regional Advisory Council (NWWRAC).

Ecosystem management in the area is largely through European Directives (Natura 2000), map of proposed or existing sites SAC etc., for Ireland and the UK arepresented below.

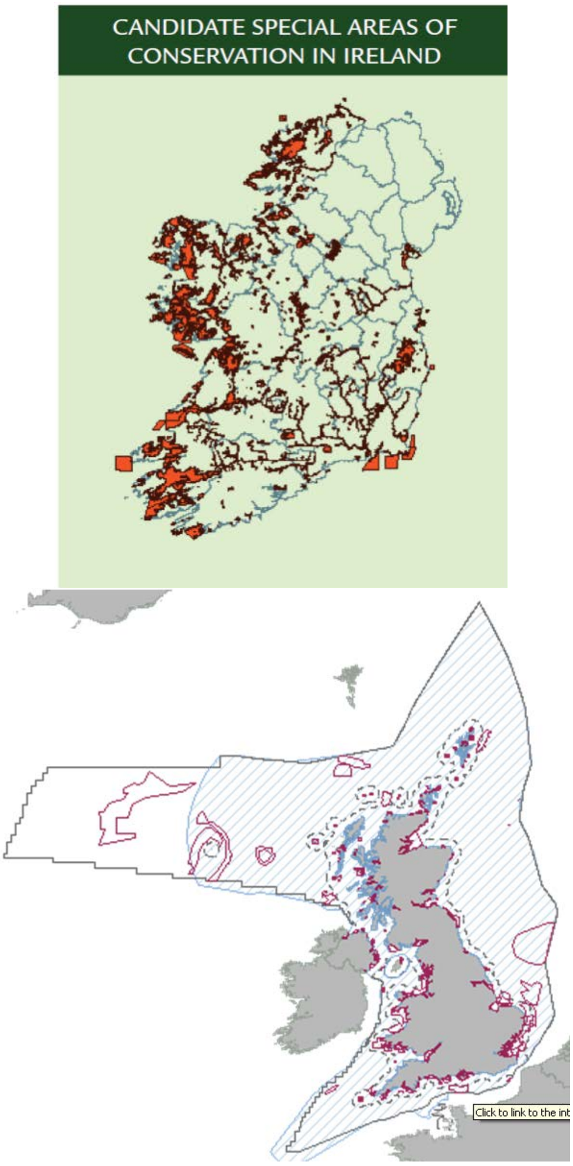
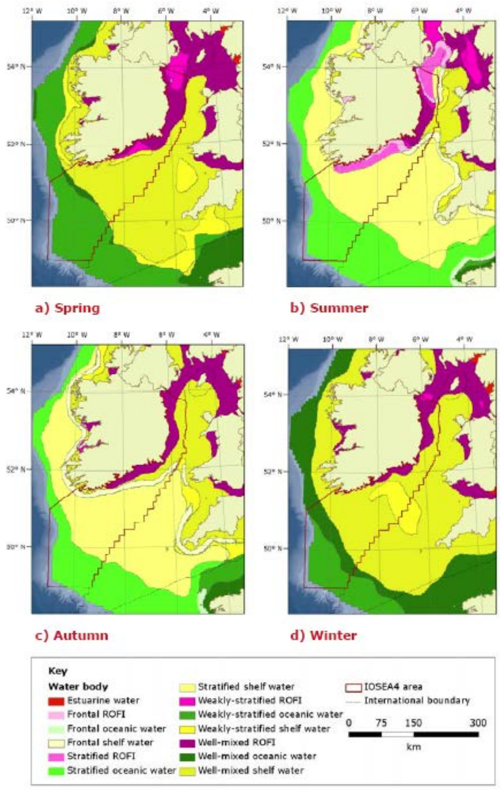


Figure 1.4. Special Areas of Conservation for Ireland (left) and the UK (right)

2 Key Signals

2.1 Physical and chemical oceanography

Figure 2.1.1 shows the seasonal variation in the water masses found in the area (Connor et al 2006). The waters in the area are generally stratified in summer and autumn and then mixed in winter and spring. The main features of the circulation are presented in Figure 2.1.2.. The main features are the frontal regions at the entrances to the Irish Sea and English Channel (Celtic Sea and Ushant Fronts), and the Western Irish Shelf Front. The other main feature is the Irish Slope current, which is part of the wider European Shelf Edge Current. This is generally poleward in winter and spring, but can reverse in summer. There are also gyres found in the area of the Goban spur and Porcupine Bank.



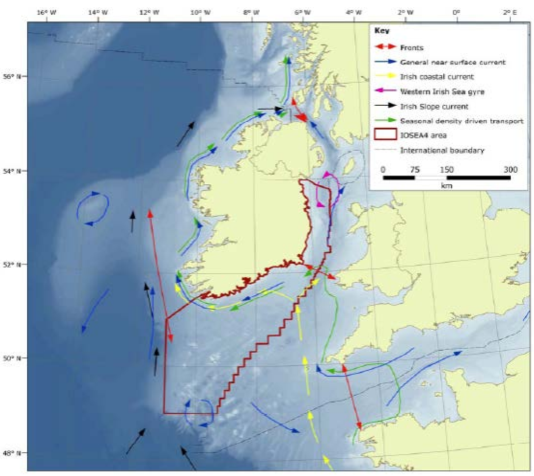


Figure 2.1.1. Seasonal variation in water bodies in the vicinity of the Celtic Seas (Source: Connor et al., 2006). (Left)

Figure 2.1.2. Main features of the oceanic circulation in the Celtic Seas. (Right)

METRIC	TEMPORAL MEASURE	DEFINITION OF SPACE	PRODUCT DELIVERED BY
Temperature (SST)	Mean monthly , integrated over water column	1, 2, 3, 4	WGOOFE & WGOH
Stratification	Timing & area by year	1	WGOOFE
Nutrients (dissolved nitrogen and phosphorus)	Winter concentrations	1, 2, 3, 4	???
Bottom oxygen depletions	Events and area	2, 3	WGOOFE
Salinity events	Events and area	2, 3	WGOOFE
Estimates of flux	Trends in fluxes	1, 4	WGOOFE & WGOH
Global climatic indices	Hurrell winter NAO index. East Atlantic pattern		WGOH
Upwelling indices	Winter and Summer trends	1,2,3,4	WGOOFE
River fluxes	Trends fluxes	1,2,3,4	????

2.1.1 Seawater temperature

Sea surface trends in the area are shown in Figure 2.1.1.2. The main feature is the steady increase observed since the last years of the 20th century. The spatial temperature anomaly pattern is shown in Figure 2.1.1.1. showing a pattern of general warming

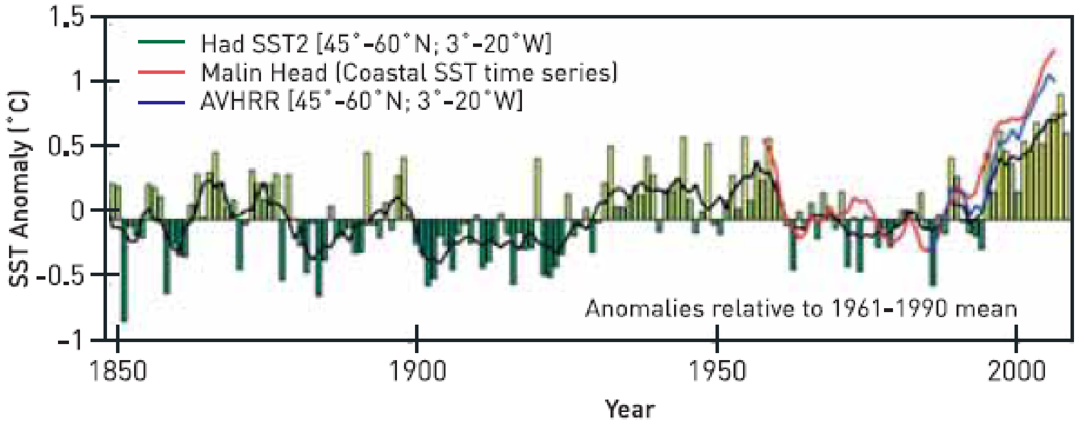


Figure 2.1.1.1. Annual mean SST anomalies (green bars), averaged over the region [45°-60°N, 3°-20°W], extracted from the HadSST2 dataset (Rayner et al., 2006) and overlain by a 5 year running mean (black line) for the period 1850-2008. AVHRR satellite derived SST anomalies for the period 1986-2006 are overlain in blue and the Malin Head coastal SST time-series from 1958-2006 in red. Anomalies are calculated relative to the 1961-1990 mean for the case of HadSST2 and Malin Head datasets and relative to the time-series climatology for the case of the AVHRR dataset (Figure from Cannaby and Hüsrevoğlu, 2009).

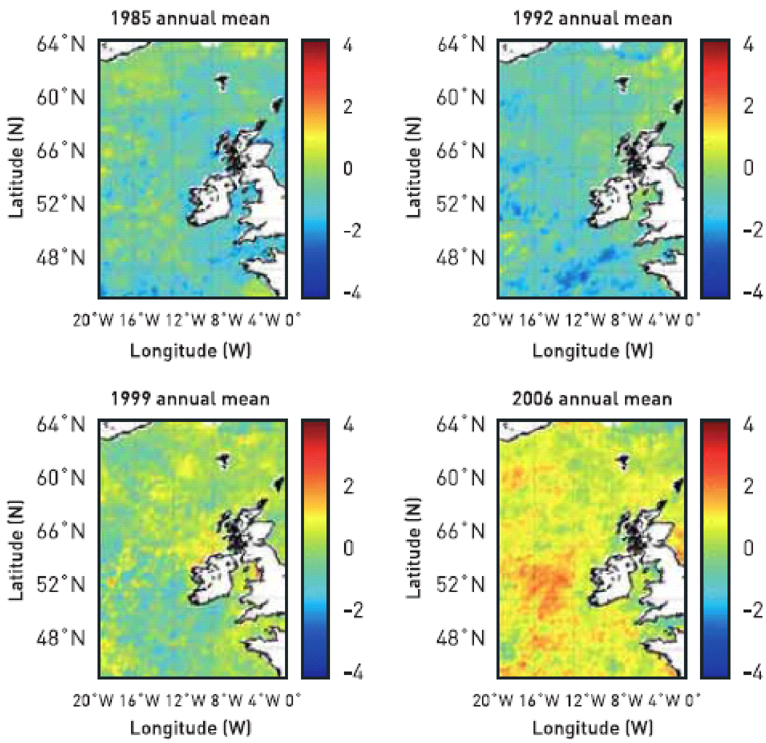


Figure 2.1.1.2. Annual mean anomalies of SST (°C) derived from level-3 processed AVHRR satellite data and calculated relative to the 1985 to 2006 climatology. Data are presented at 7 year intervals from 1985 to 2006.

Potential linkages for the shelf edge oceanography and pelagic fisheries:

- Influence of the strength of the Subpolar Gyre on spawning distribution and success of blue whiting (Hatun et al., 2009b, Hatun et al., 2009a).

- Influence of shelf edge water temperatures on migration routes for mackerel, horse mackerel and blue whiting (Blanchard and Vandermeirsch, 2005; Reid et al., 1997; Reid et al., 2001; Macer, 1977, Lockwood and Johnson, 1977, Eaton, 1983).
- Potential Influence of water temperature on recruitment for Horse Mackerel (Pipe and Walker, 1987).

The post-2006 cooling trend continues in the upper 800 m of the Rockall Trough accompanied by a freshening between 2010 and 2011. Although the potential temperature of the upper 800 m remains higher than the long-term mean, the cooling trend that started after the peak of 10.09°C in 2006 continues, with a value of 9.52°C observed in May 2011. More significantly, perhaps, the equivalent salinity, though still high, has fallen slightly for the first time since 2006 from the peak of 35.410 in 2010 to 35.398 in 2011.

2.1.2 Seawater salinity

Annual mean salinity anomalies on the Irish shelf (Figure1.2.5) exhibit a multi-annual variability which, when lagged by 7 years, significantly correlates to the NAO (Nolan 2009). No distinct salinity trends exist in deeper waters on the Irish continental shelf (i.e. water depths of ca. 200 m). Surface salinity anomalies on the Irish shelf also show variability from year to year, with evidence of freshening in coastal waters associated with increased winter rainfall. Coastal salinity records are significantly correlated to the Eastern Atlantic Pattern (EAP) (Fennell, 2008).

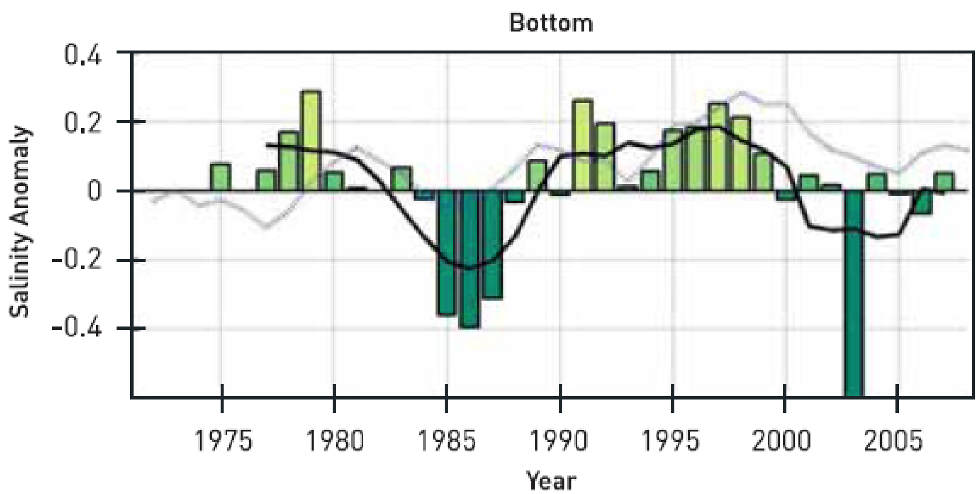


Figure 2.1.2.1. Annual mean bottom salinity anomalies on the Irish shelf (bars), overlain by a 5 year running mean (black line). Bottom salinity anomalies are overlain by a 5 year running mean of the NAO advanced 7 years in time (blue dashed). Salinity anomalies are calculated relative to the 1971-2007 climatology, and have been averaged over the region 48-58N, -15-3W

2.1.3 Freshwater run-off

Several major rivers discharge freshwater into the region and influence the circulation patterns, these are notably the River Loire, the Severn and the Irish rivers Lee and Blackwater in the Celtic Sea (Figure.2.1.3.1). To the west of Ireland, freshwater discharges from Irish rivers (e.g. Shannon) and those further afield (e.g. Loire, Severn) interact with Eastern North Atlantic Water. (Nolan and Lyons, 2006).

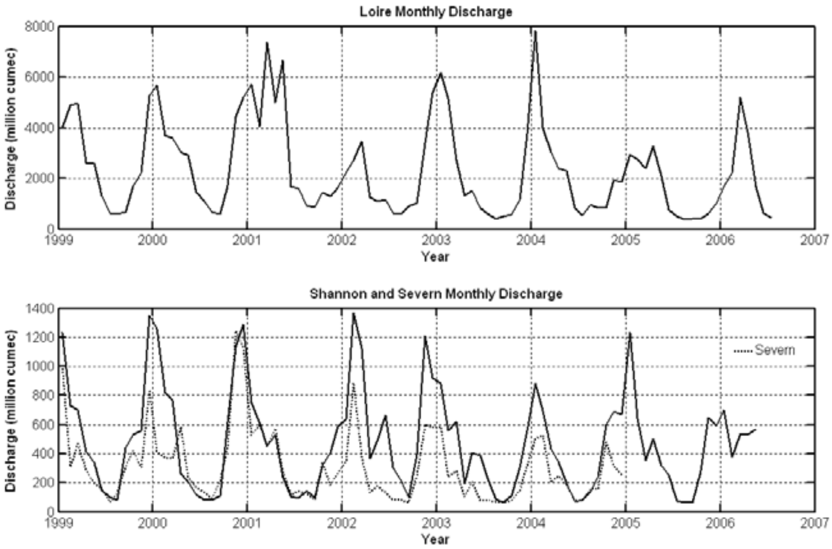


Figure 2.1.3.1. Discharges from rivers affecting the western Irish Shelf, river Loire (upper panel) and rivers Shannon and Severn (lower panel). Note different scales on Y axes.

2.1.4 Global climatic indices

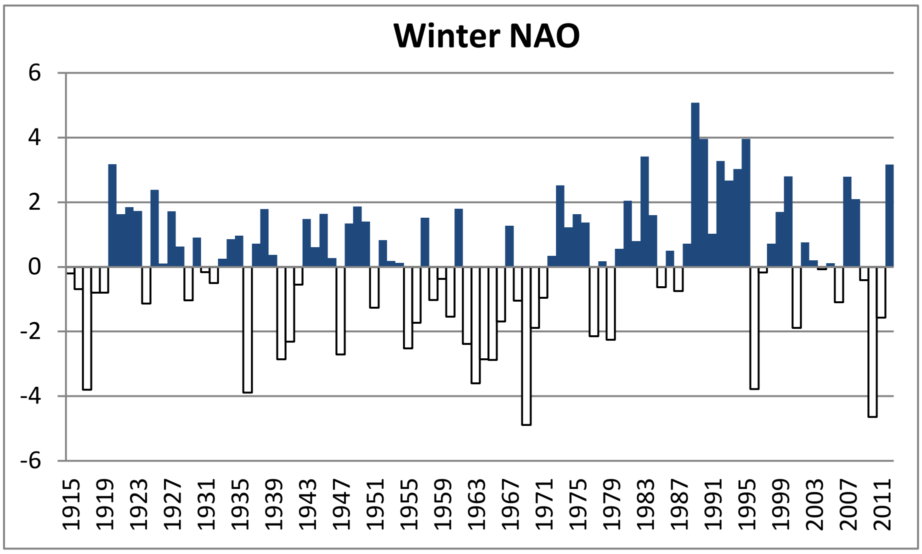


Figure 2.1.4.1. Station-based extended winter NAO index (December_March). (http://climatedataguide.ucar.edu/guidance/hurrell-north-atlantic-oscillation-nao-index-station-based).

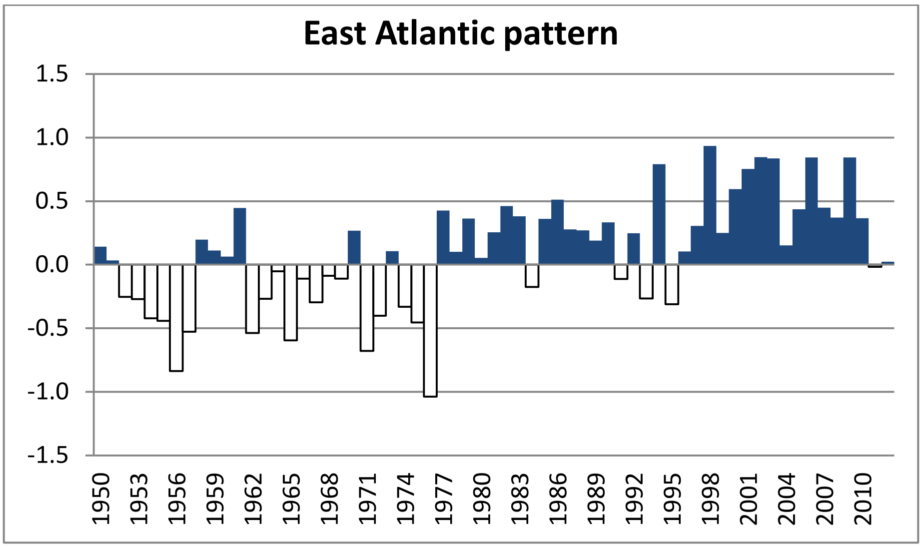


Figure 2.1.4.1. East Atlantic pattern teleconnection index (yearly average.) (http://www.cpc.ncep.noaa.gov/data/teledoc/ea.shtml).

2.2 Biotic processes

2.2.1 Phytoplankton

The seasonal pattern of phytoplankton abundance and year on year changes are presented in Figure 2.2.1.1. Showing a clear increase in diatom abundance since the late 1990s.

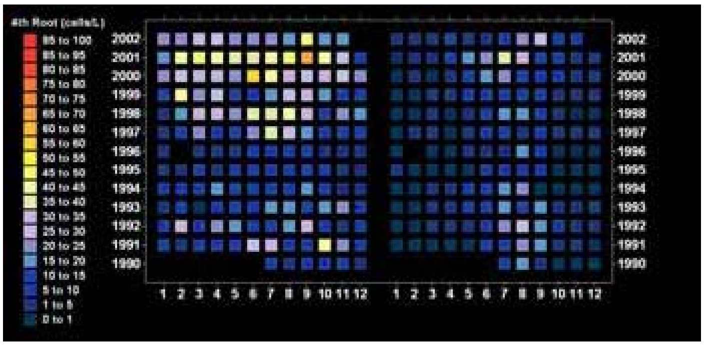


Figure 2.2.1.1. Average monthly and yearly abundance of the phytoplankton functional groups, diatoms (Bacillariophyceae) – left, and dinoflagellates (Dinophyceae) - right in Celtic Seawaters from 1990-2002 - X-axis = month; Y-axis = year; colour legend denotes numerical abundance

An increase in the intensity of colour throughout the year has been observed in the northern Celtic Sea since the late 1990s. This extension of the growth season (March-September) became most evident from 2000-2005. This means that an increase in phytoplankton colour was evident in the earlier and later months of the year (See figure 2.2.1.2, taken from Nolan 2009).

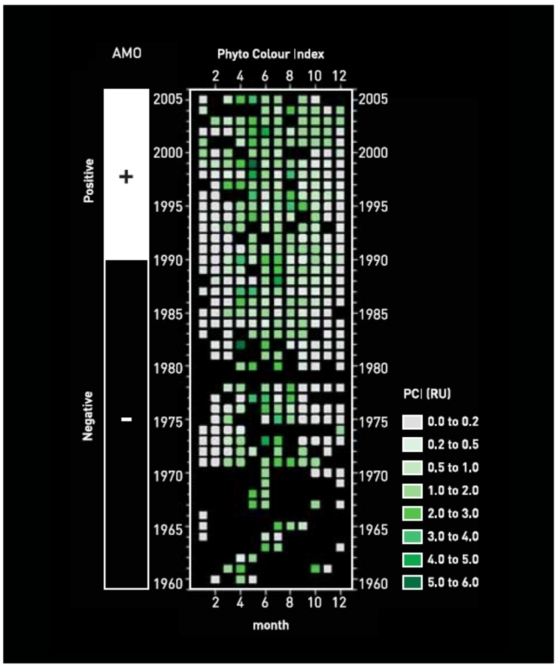


Figure 2.2.1.2. Average monthly values for phytoplankton colour (biomass) in the Celtic Sea from 1960-2005. X-axis = month; Y-axis = year; colour legend denotes numerical abundance.

2.2.2 Zooplankton

The zooplankton community in the Celtic Sea is dominated in terms of biomass and abundance by copepods, particularly the large copepod species *Calanus helgolandicus* and *C. finmarchicus*. These two species exhibit a strong geographical divide, with *C. finmarchicus* more abundant in colder more northern waters and *C. helgolandicus* abundant in warmer more southerly waters. There has been a marked increase in the abundance of *C. helgolandicus* in the Celtic Sea in recent years (Figure 2.2.2.1.)

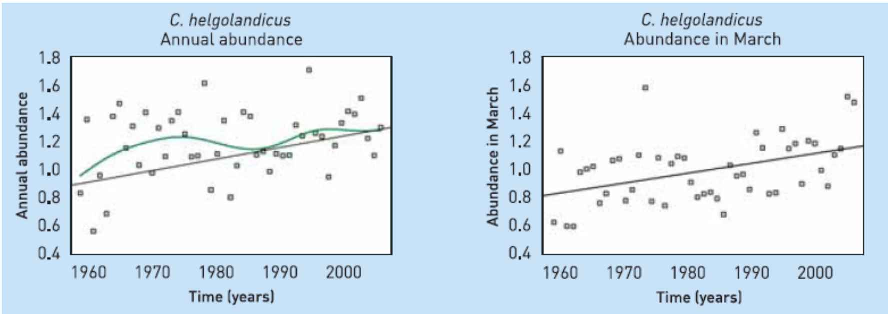


Figure 2.2.2.1. Left, mean annual abundance of *Calanus helgolandicus* in the Celtic Sea with smooth trend (green line). Right, mean abundance in March (squares). Black lines show significant ($p < 0.05$) linear trends through abundance values. NB mean values are calculated from measurements once corrected for time of day, seasonality and spatial location using a Generalized Additive Model (see Lynam et al., 2009)

In an investigation of the long-term changes in zooplankton biomass concentration and mean size, based on CPR data from 1958–2003, Pitois and Fox (2006) noted a decline in total zooplankton biomass within the Celtic Sea and in general, within northwest European Shelf waters, a northward spread of temperate species (e.g. the copepods C. helgolandicus, Pseudocalanus elongatus, Pseudocalanus spp. and the cladocerans Evadne spp and Podon spp.) and a decline in boreal species (e.g. the copepods C. finmarchicus and Euchaeta norvegica). The change in zooplankton biogeographt is shown in Figure 2.3.3.2.

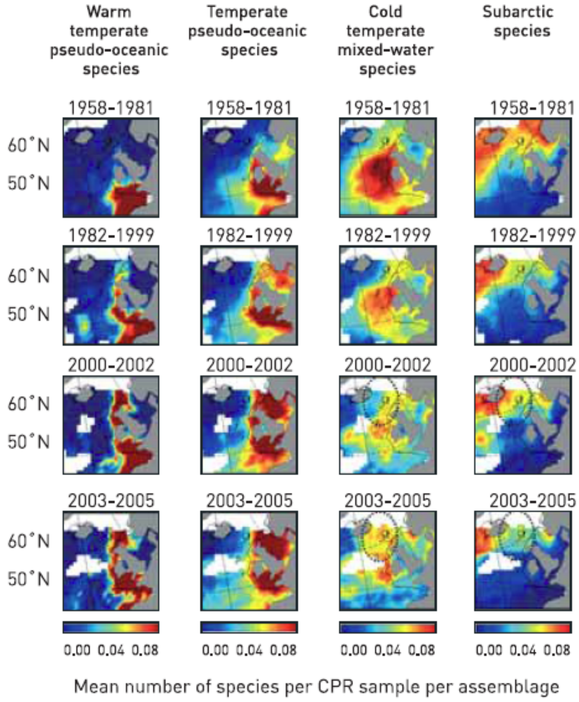


Figure 2.3.3.2. Long-term (1958-2005) changes in the mean number of species per assemblage (columns). The period 1958-1981 (row 1) was a period of relative stability and the period 1982- 1999 (row 2) was a period of rapid northward shifts. Average maximum values are rarely superior to row 1 because they include both daylight and dark periods over 2 month periods. Black dotted oval denotes areas where pronounced changes have been observed (Reproduced from Beaugrand et al., 2009).

2.2.3 Small pelagic fish

The main small pelagic fish species in the Celtic Sea are herring (Clupea harengus), blue whiting (*Micromesistus potassou*), mackerel (*Scomber scombrus*), and horse mackerel (*Trachurus trachurus*). Also found are sprat (*Sprattus sprattus*) sardine (*Sardina pilchardus*) and anchovy (*Engraulis encrasicolus*). Boarfish are a new commercial species in the area

The stock status of these species are as follows based on the latest ICES advice

- There are several herring stocks in the area.
    - Celtic Sea, Irish Sea, and West of Scotland herring - SSB is above $B_{trigger}$ and fishing mortality is under F_{MSY}
    - NW Ireland herring - SSB is below $B_{trigger}$ and fishing mortality is over F_{MSY}
- Blue whiting - SSB is above $B_{trigger}$ and fishing mortality is under F_{MSY}
- Horse mackerel – SSB in 2012 was at 1.66m tonnes but no $B_{trigger}$ has been set. Fishing mortality is over F_{MSY}
- Mackerel – SSB is above $B_{trigger}$ but fishing mortality is over F_{MSY}
- Sprat, Sardine, and Anchovy - no advice
- Boarfish - SSB is believed above $B_{trigger}$ and fishing mortality under F_{MSY}

In general, SSB status is good for most species, but deveral species (mackerel and horse mackerel) are being fished over target F.

2.2.4 Demersal fish

There is a large and diverse community of demersal fish in the Celtic Seas. Surveys have shown the presence of 140-160 different species. The main commercial species are cod (*Gadus morhua*), haddock (*Melanogrammus aeglefinus*), whiting (*Merlangus merlangius*), hake (*Merluccius merluccius*), monkfish (2 species: *Lophius piscatorius* and *L. budegassa*), megrim (2 species: *Lepidorhombus whiffiagonis* and *L. boscii*), plaice (*Pleuronectes platessa*), sole (*Solea solea*) and Pollack (*Pollachius pollachius*). Many of these stocks do not have agreed analytical assessments, and the stock status is summed up in the following table.

Species	Celtic Sea	Irish Sea	West of Ireland	West of Scotland
Cod	SSB above limits F below limits	SSB below limits F above limits	No data	SSB below limits F above limits
Haddock	SSB above limits F above limits	No assessment Stock declining	Incl. in Celtic Sea	SSB below limits F below limits
Whiting	SSB above limits F below limits	Trend assessment only – believed SSB below limits and F above limits	No data	SSB below limits F below limits
Hake1	No assessment – SSB rising	No stock	Incl. in Celtic Sea	Incl. in Celtic Sea
Plaice	Trend assessment only – believed SSB below limits and F above limits	Trend assessment only – believed SSB above limits and F below limits	No assessment	No data
Sole	No Assessment Above F limits	SSB below limits F above limits	No assessment	No data
Megrim2	No assessment – SSB rising and F stable	No stock	Incl. in Celtic Sea	SSB above limits F below limits
Anglerfish3	No assessment – SSB declining	No stock	Incl. in Celtic Sea	No assessment – SSB declining
Pollack4	No Assessment	No stock	Incl. in Celtic Sea	Incl. in Celtic Sea

1. Hake: this stock covers the whole area
2. Megrim - two stocks, one covering Biscay, Celtic Sea and west of Ireland, the other north of Ireland and the North Sea
3. Anglerfish- two stocks, one Biscay, Celtic Sea and west of Ireland, the other north of Ireland and the North Sea
4. The Pollack stock covers the whole ecoregion

The main issue for demersal stocks in the ecoregion is the lack of robust assessments, with many stocks having insufficient data for a full analytical assessment. In the Celtic Sea itself, stocks of cod, haddock, whiting, hake and megrim are believed to be healthy. Where information is available, most stocks in the Irish Sea have issues in terms of SSB or F, with the exception of sole. In the west of Scotland the situation is similar, with megrim the only example of a healthy stock.

Large Fish Indicator

Figure 2.2.4.1 shows the LFIs calculated for a range of surveys in the ecoregion (Shepherd et al in prep.). The broad conclusion would suggest that LFI decreased substantially in all areas at the start of the 1990s, and has started to show some recovery from the early 2000s. The main exception being the Irish Sea where the indicator is relatively high but has been declining.

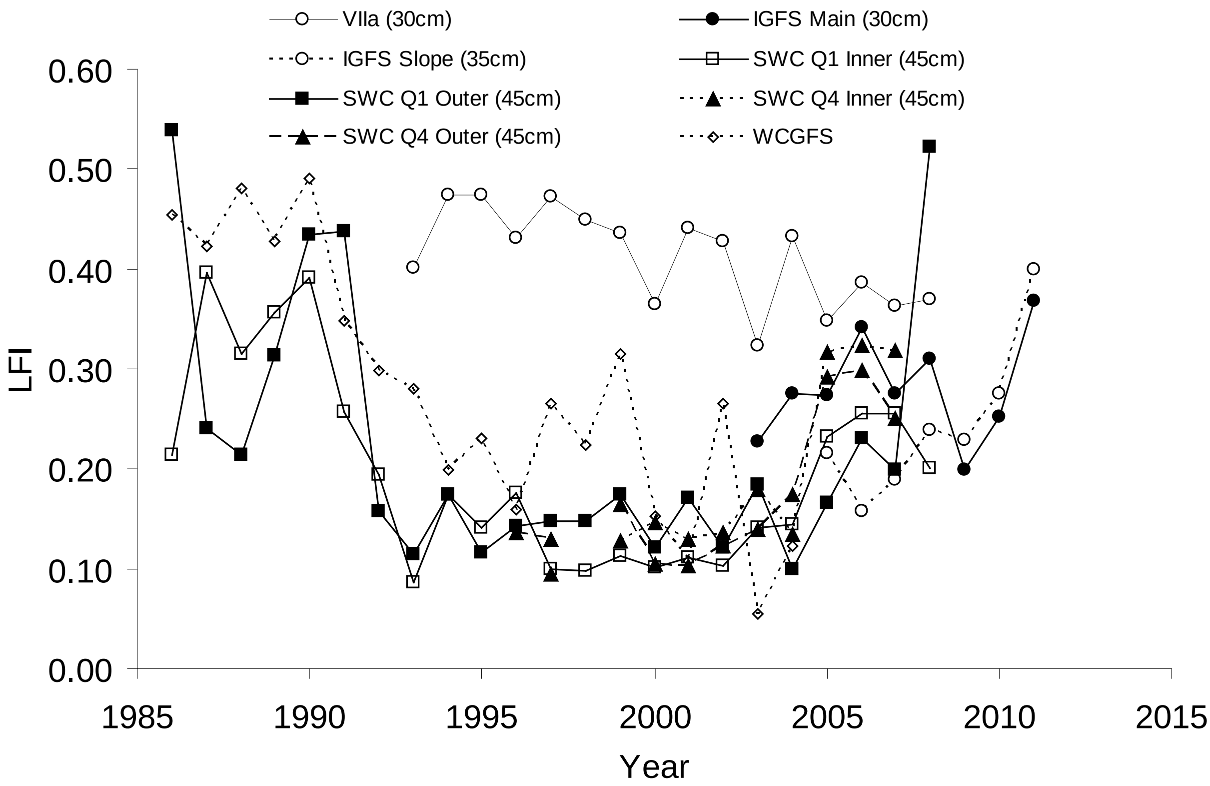


Figure 2.2.4.1. LFI time-series derived from Celtic Seas surveys / survey biogeographic regions.

2.2.5 Benthic communities

Relatively little benthic community data are available for the Celtic Sea ecoregion, and it is not possible to date to establish any trends or actions for management.

2.2.6 Marine Mammals and Seabirds

Cetaceans

Many cetacean species are found in the Celtic Seas ecoregion. Common species sighted include Common dolphin (*Delphinus delphis*), harbour porpoise (*Phocoena phocoena*), and Minke whale (*Balaenoptera acutorostrata*). Distribution maps for these are shown in Figures 2.2.6.1-3. These data are taken from the SCANS-II report (SCANS 2003). Under the Irish Whale Fisheries Act 1937 the hunting of all whale species, including dolphins and porpoises, is totally banned within the fisheries limits out to 200 miles from the Irish coast. Bycatch of cetaceans in fisheries is not considered a major problem in the ecoregion.

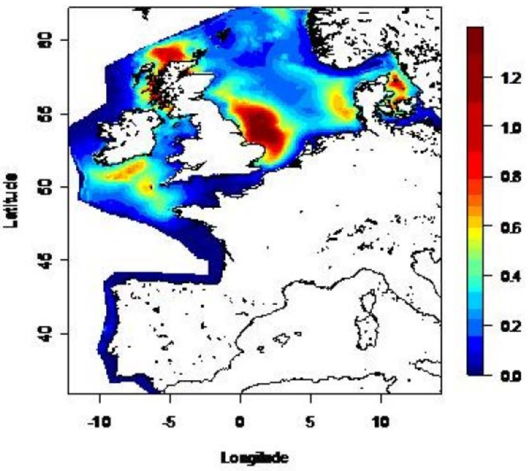


Figure 2.2.6.1. Harbour porpoise distribution

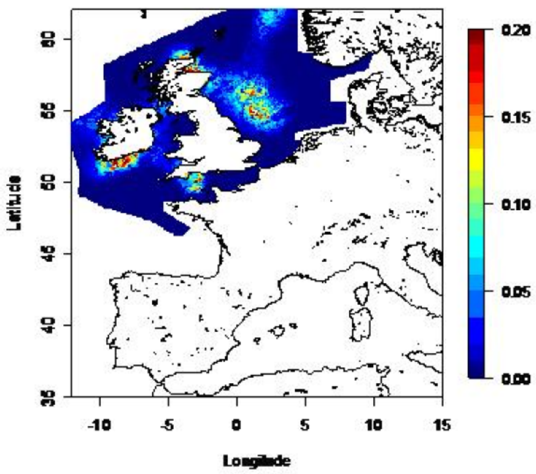


Figure 2.2.6.2. Minke whale distribution

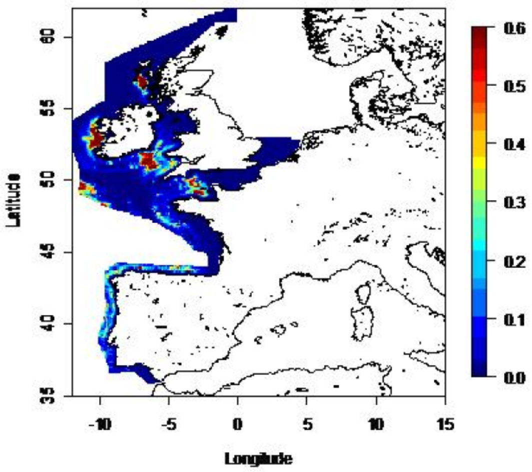


Figure 2.2.6.3. Common Dolphin distribution

Other fairly common species include; Bottlenose (*Tursiops truncatus*), white sided (*Lagenorhynchus acutus*), and striped dolphins (*Stenella coeruleoalba*), as well as Killer whales (*Orcinus orca*) and Cuviers beaked whale (*Ziphius cavirostris*). Many other species of cetacean have also been recorded in the Celtic Sea off Ireland (source: Irish Whale and Dolphin Group (http://www.iwdg.ie).

Seals

There are two common species of seal found in the Celtic Sea, grey seal (*Halichoerus grypus*), and harbour seal (*Phoca vitulina*).

Grey seal breeding colonies are presented in Figure 2.2.6.4. for Ireland and the UK. Abundance estimates are difficult for grey seal as they spend a great deal of time off shore. A proxy for abundance would be pup production. Pup production in Ireland was estimated at 1600 in 2005 (O'Cadhla et al 2007). UK estimates are only available for the whole country and were estimated at over 50,000 in 2010 and increasing.

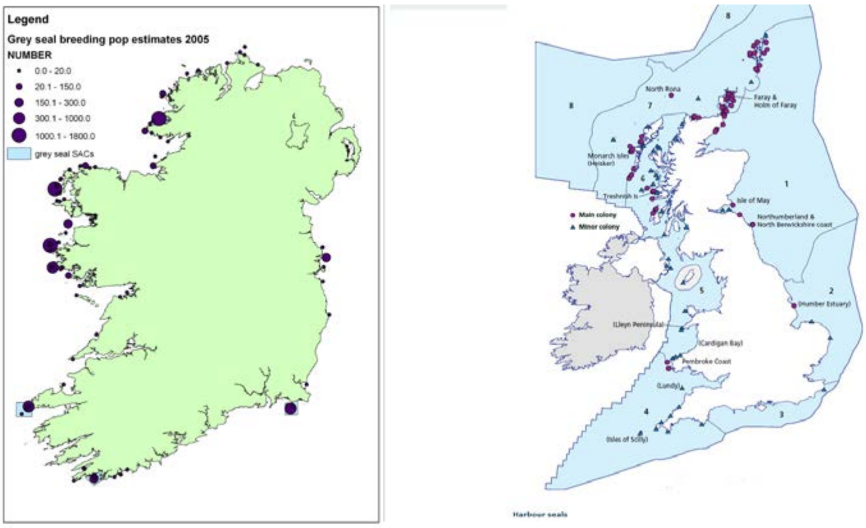


Figure 2.2.6.4. Grey seal breeding colonies in Ireland and the UK.

Harbour seal breeding colonies are presented in Figure 2.2.6.5. Abundance in Ireland was estimated at close to 7000 in the early 2000s (Cronin et al 2012), this was an increase from a previous but not directly comparable survey. Estimates (2007-09) for the west of Scotland suggest 11,400 with no trend.

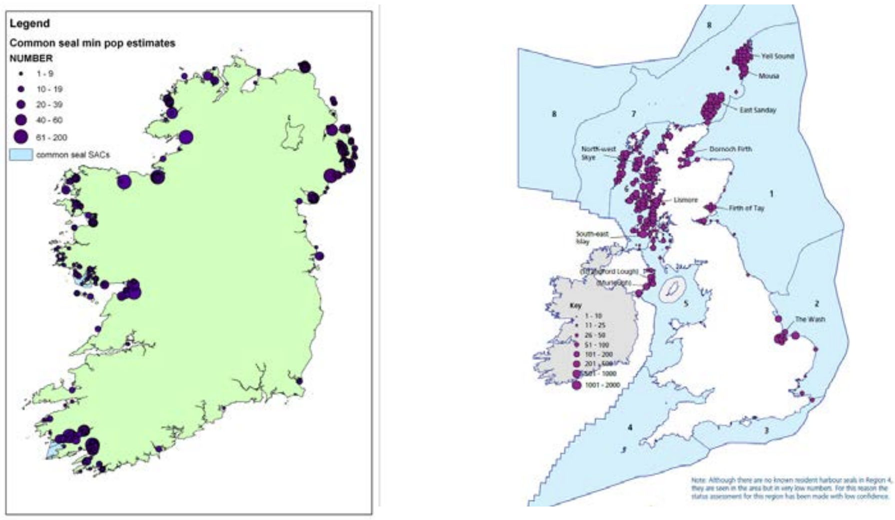
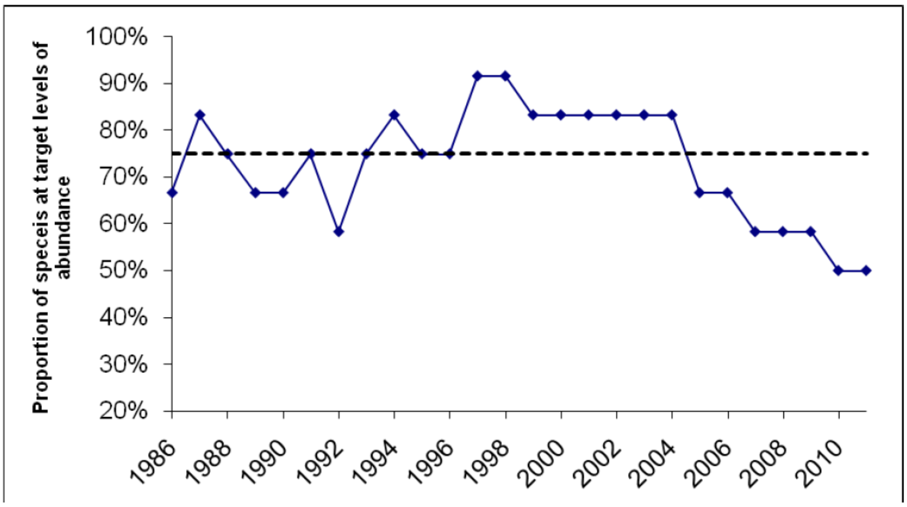


Figure 2.2.6.5. Harbour seal breeding colonies in Ireland and the UK.

Seabirds

Based on the ECOQO targets on seabird abundance trends in OSPAR region 3 (Celtic Seas), the proportion of species in OSPAR III that were within target levels during 1986-2011 was less than 60%, with a target refrence level of 70%. The time-trend is presented in Figure (The graph represents the New target option' without an upper target level of 130%) from ICES WCBIRD 2012.



The proposed EcoQO indicator on breeding seabird population trends in OSPAR region III for the period 1986–2011 was not achieved in 1986, 1989–1992, 1996 and in consecutive years during 2003–2011 and six bird species (Northern fulmar, Arctic skua, European shag, herring gull, black-legged kittiwake and roseate tern), are all below the lower target baseline levels.

2.3 Human impacts

The OSPAR QSR 2010 considered a wide range of human pressures on the marine ecosystem. The synopsis for OSPAR Region III is presented below. This highlights there areas of greatest concern, and these were; Habitat damage, Introduction of non-indigenous species, and removal of species. The first and last of these are strongly related to fishing activity, while the non-indigenous species can come from a range of sources. The key ecosystem element facing issues from non-indigenous species was seabirds.

Region III

		Fish	Cetaceans	Seals	Seabirds	Rock & biogenic reef habitats	Shallow sediment habitats	Shelf sediment habitats	Deep-sea habitats
Climate change	Climate change	L - N	L - L	L - M	L - L	L - N	L - L	L - N	-
Hydrological pressures (local)	Temperature changes (local)	-	-	-	-	-	L - H	-	-
	Salinity changes (local)	-	-	-	-	-	L - H	-	-
	Changes in water flow, wave action & emergence regime (inshore/local)	-	-	-	-	-	L - H	-	-
Pollution & other chemical pressures	Contamination by hazardous substances	L - L	L - L	L - L	L - M	L - M	L - L	L - L	-
	Radionuclide contamination	-	-	-	-	-	-	-	-
	De-oxygenation	-	L - M	L - M	-	-	L - M	L - L	-
	Nitrogen & phosphorus enrichment	-	L - M	L - M	-	L - M	L - M	L - M	-
	Organic enrichment	L - M	-	-	-	L - H	L - M	L - L	-
Other physical pressures	Electromagnetic changes	-	L -	-	-	-	-	-	-
	Litter	L - H	L - L	L - L	-	-	-	L - L	-
	Underwater noise	L - H	L - H	L - H	-	-	-	-	-
	Barrier to species movement	-	L - H	L - N	L - H	-	-	-	-
	Death or injury by collision	-	L - L	L - L	L - H	-	-	-	-
Habitat changes	Siltation rate changes	L - H	L -	L - N	-	L - M	L - M	L -	-
	Habitat damage	L - L	L - M	L - L	L - M	L - L	M - M	M - L	-
	Habitat loss	L - N	L - L	L - L	L - N	L - N	L - N	L - L	-
Biological pressures	Visual disturbance	-	-	-	-	-	-	-	-
	Genetic modification	-	-	-	-	-	-	-	-
	Introduction of microbial pathogens	-	L -	L - M	-	-	-	-	-
	Introduction of non-indigenous species &	L - H	-	-	M - L	L - M	L - N	L -	-
	Removal of species (target & non-target)	M - L	L - L	L - M	L - M	L - M	M - M	M - L	-
	Total impact	12	14	13	10	9	17	15	0

	Fish	Cetaceans	Seals	Seabirds	Rock & biogenic reef habitats	Shallow sediment habitats	Shelf sediment habitats	200-1000m	Deep sea >1000m
Status assessment	Moderate	Moderate	Good	Moderate	Moderate	Moderate	Moderate	Not present	Not present
Confidence in status assessment	High	Very low	High	High	High	High	High		

Fishing activity in the various areas of the ecoregion have been calculated for Irish vessels and are summarized in the following figures (2.3.1 and 2.3.2). Fishing activity in the west of Scotland (VIa) has been declining steadily since 1995. In the Irish Sea (VIIa) activity is much lower, peaked in 1999 and has been declining since. In the Celtic Sea (VIIf,g,h,j,k) activity peaked in 2003 and has been declining since. In the west of Ireland (VIIb,c) activity again is much lower, peaked in 2004 and has been declining since. So in all the main fishing areas around Ireland, fishing activity has been declining since 2004, and in many cases earlier.

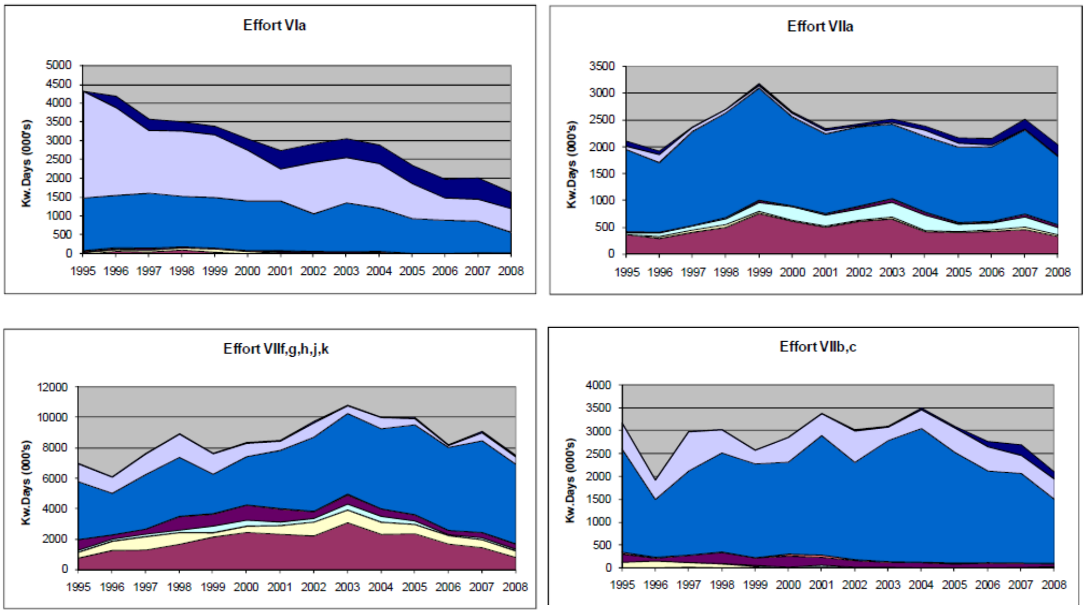


Figure 2.3.1. Fishing activity in the main fishing areas in the Celtic Seas Ecoregion. Since 1995. Source Anon. 2009.

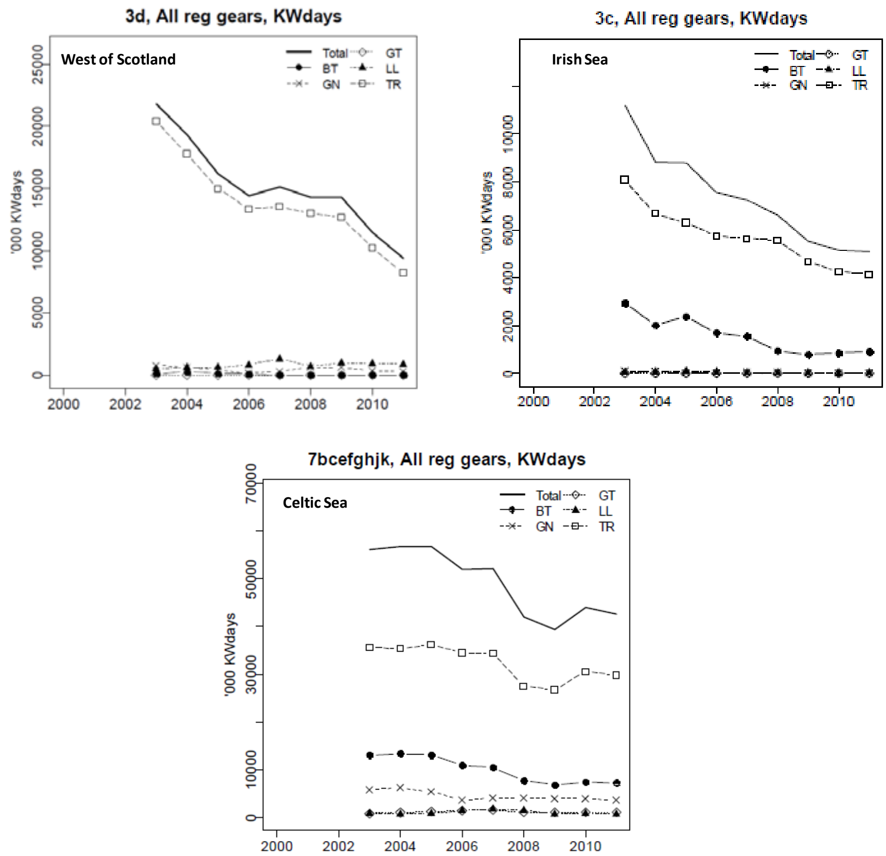


Figure 2.3.2. International fishing activity by main gear code in the main fishing areas in the Celtic Seas Ecoregion. Since 1995. Source STECF. 2012.

3 Activity and Pressure

3.1 Activity

3.1.1 Fishing

Fishing can be considered as one of the main activities in the region. Fishing activity by area and year for the main gear groups are presented above. The spatial distribution of international fishing activity is presented in Figure 3.1.1.1.

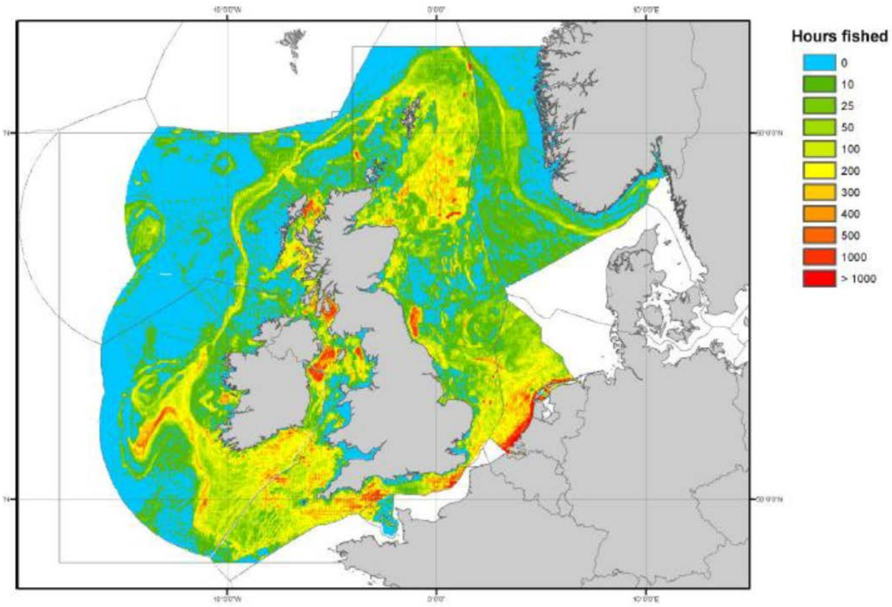


Figure 3.1.1.1. example fishing activity plot based on VMS data. Calculated based on 2006 VMS data from submitting nations for all mobile bottom gears com-bined. From Le Quesne et al 2010 MEFEPO North Sea GES report. See Le Quesne et al 2010 for description of methods. [Le Quesne et al. 2010Assessing the impact of fishing on the Marine Strategy Framework Directive objectives for Good Environ-mental Status. MEFEPO FP7 project WP2 report. www.liv.ac.uk/mefepo/.]

3.1.2 Physical alterations of the seabed

3.1.2.1 Built environment,

This area has a large number of artificial structures along its coastlines (figure 3.1.2.1). These include land reclaimed for port and industrial zones; coastal defenses such as dykes, seawalls and beach nourishment schemes to prevent erosion and protect against flooding; as well as aquaculture infrastructure; shipping channels; residential development; tourist accommodation; roads; piers; marinas and wastewater treatment facilities that cater for a growing population and tourism demands. A projected 47 cm rise in sea level in the Irish Sea by the end of the century (NUIG, 2012) and increase in storm frequency and intensity (Olbert and Hartnett, 2010) is likely to increase the need for more coastal defence infrastructure.

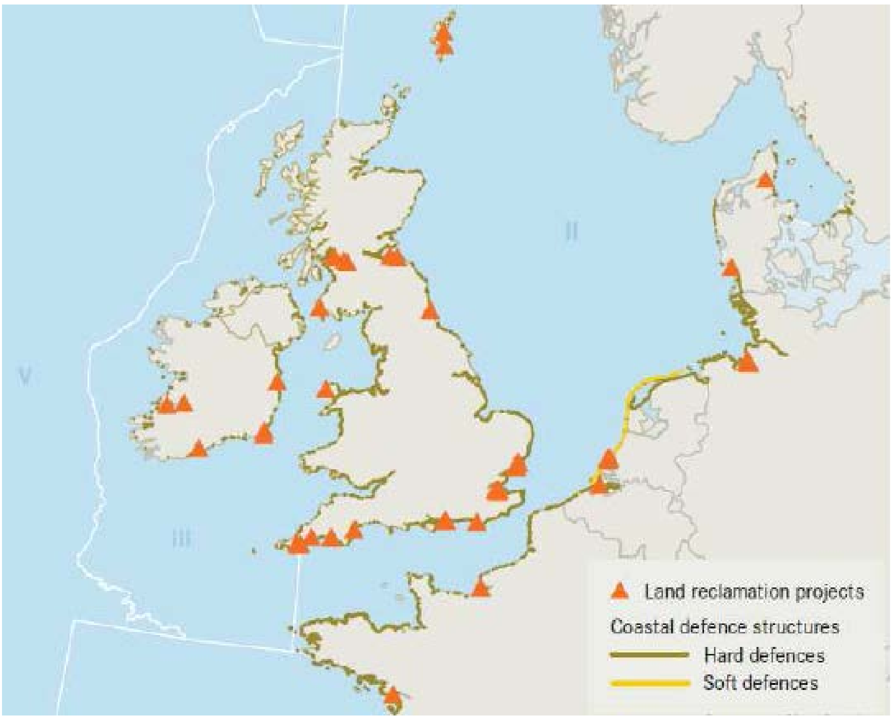


Fig 3.1.2.1. Location of land reclamation projects (orange triangle) and hard (green outline) and soft (yellow outline) coastal defence structures (OSPAR, 2010a)

Impacts

Typical habitats affected by land reclamation and coastal construction include sandbanks, estuaries, mud flats, saltmarsh and dune systems/beaches (OSPAR, 2010a). Hard-engineered coastal structures can change ecosystems by creating new hard-bottom habitats that attract rocky reef fish and invertebrate species that would not normally be found at the site. Soft-engineered schemes using dunes and saltmarsh are the preferred option as they act as natural buffers and work with the environment rather than try to divert it.

As artificial structures are put in place the natural flow of sediment (clay, silt and fine sands) is disrupted and can cause a build-up of suspended and settled material and growth of new species such as cordgrass (*Spartina* spp.) that are tolerant of salt and anoxic conditions. Sediment accretion (land mass increases caused by water-borne sediment deposition) and sediment release issues associated with this species have been known to cause significant siltation problems in coastal wetlands such as Cork Harbour (Devoy, 2008). The result can affect the suitability of spawning grounds and lead to the loss of public amenities such as beaches and overwintering sites for migrating birds (OSPAR, 2010a).

Likely Trends

Land reclamation, coastal defence and other coastal infrastructure are likely to continue to be constructed with concomitant potential impact on the marine ecosystem. In Ireland, and probably the UK, the current economic climate may mitigate this to some extent.

3.1.2.2 Tourism and leisure,

The bulk of the coastline in this ecoregion is heavily dominated by the tourism industry, as shown by the map of leisure harbours in figure 3.1.2.2.

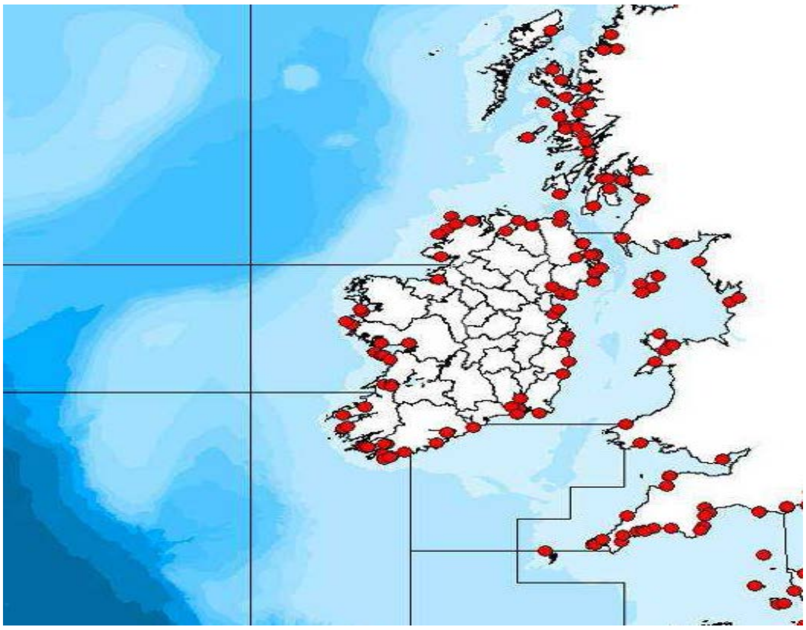


Fig 3.1.2.2: Leisure ports along the Irish Sea coastline (source: Nolan et al., 2011).

Pressures and State

Many pressures exist on natural and built infrastructure from the influx of visitors. These include:

- **Large numbers of visitors** to beaches, dunes, cliffs and wetlands
- **Sport fisheries and divers** may intentionally/unintentionally remove non-authorized or protected species
- **Species viewing trips** can potentially collide with their target
- **Leisure activities and craft** may disturb fish spawning areas
- **Non-native organisms** being transferred on visiting craft
- Run-off from inadequate sewage treatment facilities in the coastal zone
- **Litter** left by visitors or washed up on beaches. Surveys undertaken on behalf of OPSAR's Marine Litter Report (OSPAR, 2009c) found reference beaches along the Celtic Seas coast contained ~700 items per 100 m (figure 3.1.2.3). This is not only an aesthetic problem but can create health hazards

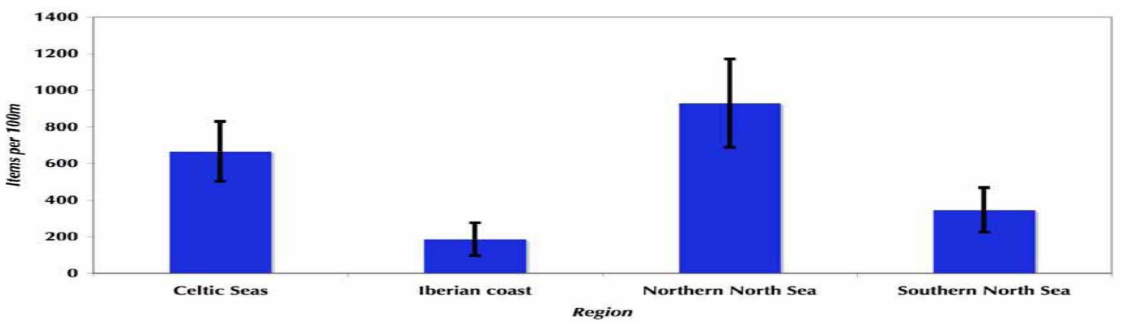


Fig 3.1.2.3. Average number of marine litter items per 100 meters on the reference beaches

Impacts

Potential impacts from tourism based activities are related to the loss of habitat and species:

- **Erosion or degradation** of terrestrial habitat e.g. beaches, dunes and cliffs not only create physical hazards to visitors but can create a sediment build-up in the shallows and smother shallow benthic communities
- **Beach-dwelling and protected breeding species** like the little tern may be impacted by large numbers of visitors. Wardening projects at nesting sites in Baltray, Co. Louth and Kilcoole, Co. Wicklow fence off sections of the beach each breeding season to protect the eggs and chicks until fledged (www.louthnaturetrust.org and http://littleternconservation.blogspot.ie/)
- **The unauthorized taking of species** such as cold-water corals is the same as removing both a species and habitat

Likely Trends

Tourism and leisure development is likely to continue throughout the area, with concomitant impacts on the marine ecosystem. In Ireland, and probably the UK, the current economic climate may mitigate this to some extent.

3.1.2.3 Renewable energy sector

To date, foreshore leases have been granted for the operation of two offshore wind power sites in the Irish Sea - a 520 MW wind farm on the Arklow Bank and a 1,100 MW wind farm on the Codling Bank. Approximately 800 MW of offshore wind projects have applied for foreshore leases and are due to receive an offer of a grid connection. These include the Dublin Array (off Bray Head, Co Wicklow) (364 MW); Oriel (Dundalk Bay, Co Louth) (320 MW) and Doolick (Outer Galway Bay, Atlantic coast) (100.8 MW) (figure 3.1.2.3.) (DCENR, 2012a).

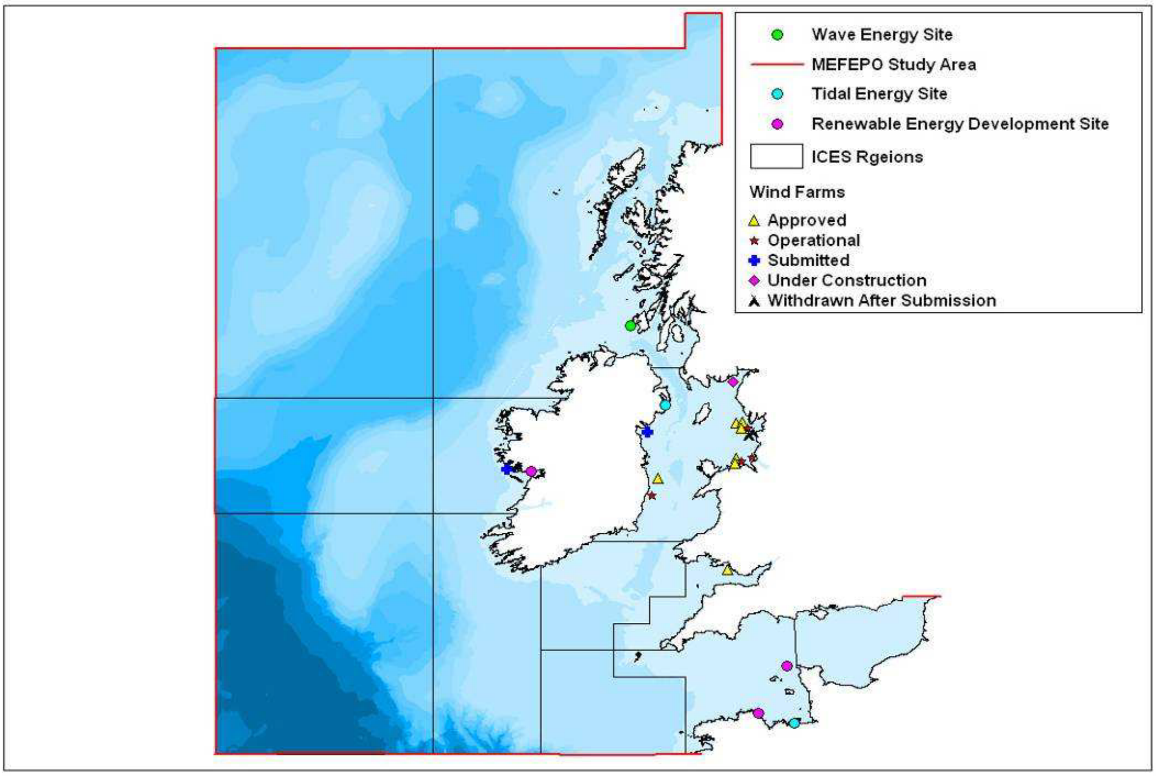


Figure 3.1.2.3. Wave and tidal energy extraction sites in the Celtic Seas Ecoregion.

Ireland's first full-scale wave energy test site has been proposed at Belmullet, Co. Mayo (Atlantic Marine Energy Test Site) (Hunt et al., 2011, Scally et al., 2011). In August 2012 an application for a foreshore license was lodged with the Department of the Environment to investigate the potential of generating 5 MW of wave energy at an 8.8 km^2 site off the west coast of Co. Clare
No tidal energy technology applications are known of.

Pressure and State

As marine renewable technologies are relatively new environmental pressures have yet to be fully understood as some devices have yet to be fully tested *in-situ* (Boehlert and Gill, 2010). Wave and tidal power generation both have the potential to alter water column processes (ICES, 2010a). Wave capture acts as a wave breaker and mixing of the upper layers may slow down whereas tidal power could increase turbulence in the water column.

Our current ability to model short and long-term risks to specific species is also poor (Stewart et al., 2007). It has been suggested that use of remote Thermal Animal Detection Systems (TADS) using infrared video cameras (Desholm et al., 2006) and weather, military and air traffic control surveillance radar be employed to define areas, routes and behaviour of migrating animals (Fox et al., 2006). It is also known that mammal and fish species have sensitive hearing and additional noise above natural background levels (wind turbines can generate noise up to 140 dB re 1μPa (Mueller-Blenkle et al., 2007)), may interfere with communication channels (Mueller-Blenkle et al., 2007, Mueller-Blenkle et al., 2008).

There has been very little research into the impact on the seabed or marine species from electromagnetic fields (EMF) generated by the transmission of power through submarine cables (Gill, 2005, Boehlert and Gill, 2010). Where it is known/thought that some taxa e.g.: seabirds, cetaceans, herptiles, benthic elasmobranchs, migratory fish and eels depend on geomagnetic fields for orientation (Gill and Taylor, 2001, Ohman et al., 2007, Gill et al., 2012), the lack of a baseline and threshold values of individual species makes it difficult to form any useful conclusions (Acres, 2006, Gill et al., 2012). Cables carrying direct current (DC) however are likely to carry only 10-15 kV, which is unlikely to generate an electrical field more than a few centimetres from the cable (ICES, 2010a).

Impacts

Physical and biological impacts to the seabed such as habitat loss; the creation of new substrata, combined artificial reefs and fish aggregation devices and benthic regeneration during construction and removal phases have already been discussed in relation to fishing , built environment, aggregate extraction and the oil and gas industries. Other potential impacts include:

- **The removal or capture of wave or tidal energy** could increase levels of suspended sediments. The resulting turbidity may affect species that rely on visual cues
- The frequency of **seabirds collisions** with wind or tidal turbines and other surface infrastructure is negligible and dependent on the species (OSPAR, 2010a). Migration flyways or local flight paths may be altered to avoid these installations (Desholm and Kahlert, 2005, Drewitt and Langston, 2006, Masden et al., 2009)

- There is insufficient information available to determine the likelihood of **marine mammals** colliding with subsurface structures. It is suggested that species that are agile and able to echolocate are unlikely to not detect these structures (ICES, 2010a)
- **Temporary or permanent changes to shipping lanes or fisheries** to accommodate these installations could create greater distances between points A and B. This in turn will result in higher fuel costs and increased emissions to the atmosphere

Likely Trends

This sector is very likely to expand significantly in the near future given policy drivers and the costs of fossil fuels. There will also likly be an expansion of some of the less explored options such as tidal energy.

3.1.2.4 Cables and pipe laying,

The ecoregion has significant numbers of submarine cable installations, particularly for transatlantic connections (figure 3.1.2.4) (Nolan, 2009b).

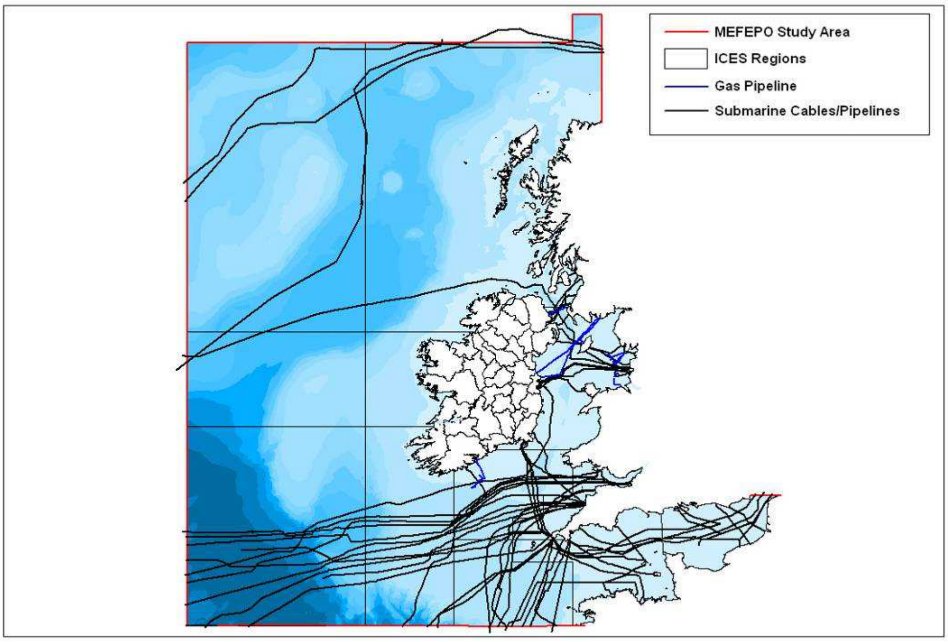


Figure 3.1.2.4. Submarine cables in the Celtic Seas Ecoregion (Nolan et al 2011).

Pressures and State

Since the middle of the 19th century more than 300 long-distance cables have been laid within the OSPAR maritime area. This includes about 40 transocean connections (OSPAR, 2008). Most subsea cables in the Irish Sea connect Dublin and Belfast to the northwest of England and southern Scotland. Cables are usually buried to avoid the potential of damage by anchors or fishing gear. Each substratum type has a recommended burial depth e.g. course sand and gravel at 0.4 – 1.0 m depth (OSPAR, 2009b). In areas of exposed bedrock they are laid directly on the seabed and may be covered by a protective structure such as a rock-mattress cover, cast iron shells, cable anchoring, ducting or rock dumping. Known pressures include (OSPAR, 2008):

- Temporary underwater noise caused by machinery or vessels during installation, maintenance and removal. Compared to seismic surveying, pile hammering and drilling activities noise generated from pipe laying is considered to be more moderate
- Vibrations during operation (depending on the type of activity and cable used) may be detrimental to benthic organisms
- Temporary and localized disturbance to the benthos and seabed habitats during laying
- Disruption to fish and mammal orientation by the emission of electromagnetic fields
- Possible temperature effects of operating cables on substrata and benthos suggest they should be buried at an appropriate depth

Impacts

When encasing materials are made of non-local sediment, changes in the structure of local soft-bottom communities in the immediate vicinity of the 'artificial reef' could be expected. The larvae of sessile encrusting organisms e.g.: encrusting corals, sponges, anemones have been observed settling on and colonizing cable surfaces (OSPAR, 2008). Cables or pipelines could also release contaminants if they are not removed after decommissioning, if they are damaged at any time during their lifetime or if fluid-filled cables are used.

Likely Trends

It would appear unlikely that any large number of major new cables or pipelines will be constructed in the near future, exceptions' may include the new proposed power connections between the UK and Ireland.

3.1.2.5 Mariculture

Mariculture is the cultivation of marine organism such as finfish and shellfish for food and other products. For 2009 303 separate enterprises within Ireland employed nearly 2,000 full time, part-time and casual workers (figure x) (STECF, 2012b). Collectively these enterprises produced 47,407 t with an annual turnover of €106m and a Gross Added Value of €34m. When broken down into finfish and shellfish components for the same year shellfish production was 33,365 t with a turnover of €35m and finfish was 13,842 t and €71m. Cultured species include Atlantic salmon (*Salmo salar*) (figure x), rainbow trout (*Oncorhynchus mykiss*), Arctic char (*Salvelinus alpinus*), European perch (*Perca fluviatilis*), turbot (*Psetta maxima*), blue mussel (*Mytilus Edulis*), Pacific oyster (*Crassostrea gigas*), flat/native oyster (*Ostrea edulis*), king scallop (*Pecten maximus*), clam (*Ruditapes philippinarum*), abalone (*Haliotis spp.*), urchin (*Paracentrotus lividus*) and algae species (*Laminaria digitata*, *Palmaria palmata*, *Alaria esculentia*).

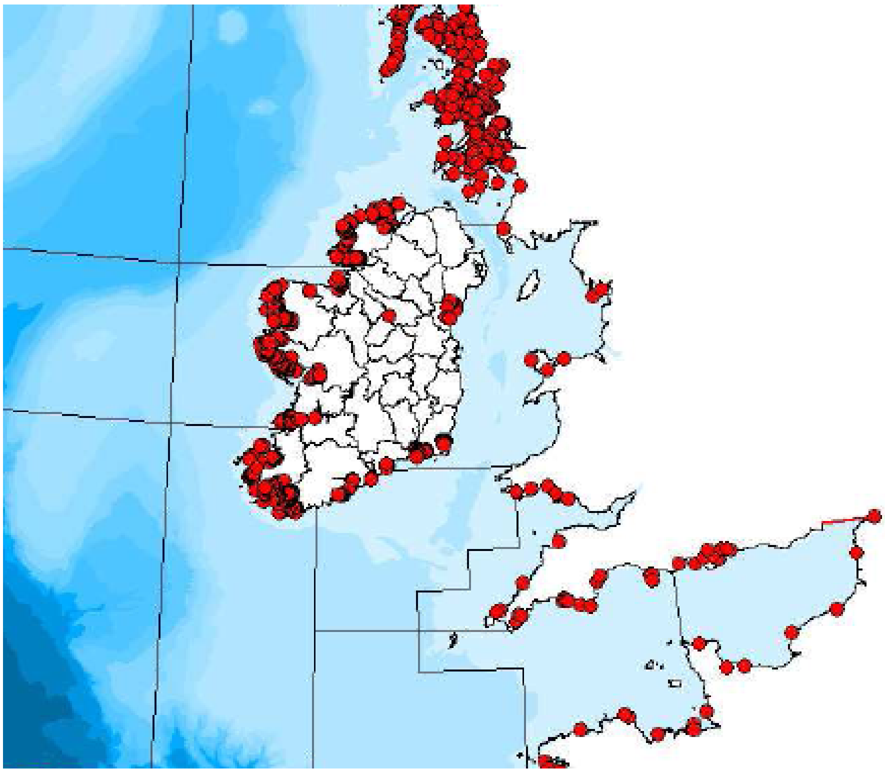


Figure 3.1.2.5. Mariculture sites located in the Celtic Sea region (Nolan et al., 2011).

Pressures and State

Unless indicated, the following summary is based ICES advice (ICES, 2010b).

- **Escaped larvae and fish** have the potential to significantly dilute the genetic diversity in local wild populations, particularly if the wild stock is already in a poor condition. There is a risk that escaped farmed fish can compete with wild stocks for spawning grounds to produce feral stocks (Naylor et al., 2005)
- **The proliferation of parasites** is possible in densely populated fish farms and there is the potential for them to pass onto passing wild fish (MacKinnon, 1998, Costello, 2006, Krkošek et al., 2006, Frazer, 2009, Costello, 2009). *Caligus elongates* Nordmann and *Lepeophtheirus salmonis* Krøyer lice species are found in Irish waters (O'Donohoe et al., 2012)
- **Chemical and biochemical oxygen demand (COD and BOD)** are a consequence of the breakdown of organic matter (e.g. feacal matter and uneaten food) from fish farms. This can lower oxygen levels in the sediment and water column
- **Ammonia and salts of nitrate and phosphate** are released into the water column as by-products of fish excretion and decaying food
- **Uses of synthetic compound chemical treatments (e.g. disinfectants and antibiotics)** have the potential to diffuse into marine waters by a variety of routes such as water treatments, spills, waste food and faecal matter
- **Heavy metal contamination** from copper and zinc has been reported in Scotland and Canada. The principal sources are anti fouling paints and fish feed

- **Introduced species** to supplement or assist local culture activities can become established. The warm-water Pacific oyster (*C. gigas*) is a good example of this. It was introduced into European coastal waters in the mid-1960s and 1970s for commercial purposes (Drinkwaard, 1999) and has now become established in Lough Swilly (Co. Donegal) (Anon., 2011b)
- **Feeding carnivorous mariculture species wild-caught fish** from a lower trophic level ('fishing down and farming up' the foodweb (Pauly et al., 1998) can deplete wild stocks (usually pelagic species such as sandeel, herring, anchovy)
- **Water flow rates and wave exposure** levels may be changed by site infrastructure (e.g. fish pens, floats, shellfish rafts). This could alter and disturb surrounding habitats
- **Harvesting operations** that cause disturbance to the seabed (e.g. seed harvesting or dredging for oysters or mussels) can cause physical damage to benthic habitats

Impacts

- **Lice infestations** are of concern because they can damage fish scales and cause secondary infections which can ultimately reduce marketability (O'Donohoe et al., 2012)
- **Increases in nutrients in the water column** with the right environmental conditions can lead to excessive phytoplankton/algae growth and change water column characteristics
- Reduce benthic diversity and increased opportunistic species could result from changes in water characteristics
- **Non-native species** that become established can have the potential to out compete indigenous species and hence affect the stability of foodwebs
- **The removal of pelagic species** for fish-feed may have consequences for the breeding success of piscivorous water birds such as kittiwakes and puffins.
- Marine species (seabirds and mammals) can ingest, become entangled or smothered by off-casts or accidental loss e.g. broken nets, plastic pipes and metals

Likely Trends

The FAO anticipates a worldwide growth in mariculture, and this is expected to also occur in this ecoregion. Of particular not is the recent move to offshore fish farming.

3.1.3 Physical alterations to the seabed

Aggregate extraction etc

Volumes of aggregates extracted across Europe vary. In 2007 the UK extracted nearly 14 million m^3, the France 6.5 million m^3 and Ireland 1 million m^3 (figure 3.1.3.1) (OSPAR, 2010a).

Fig 3.1.3.1. Volumes in m^3 of aggregates extracted by Ireland, the UK and France. Orange = sand and gravel and yellow = maerl (OSPAR, 2010a)

Pressure and state

The two main extraction techniques are (1) anchor dredger and more commonly (2) trailer-suction dredger. Anchor dredgers excavate from a fixed mooring point and can create deep crater-like depressions, whereas trailer suction dredgers are mobile and traverse a licensed area like a tractor ploughing a field creating furrows along the seabed. It has been found that seabed recovery from aggregate extraction requires a longer period than from benthic fishing (Foden et al., 2010). Affected areas can be re-colonized by polychaetes within 5-10 months of cessation of dredging (Kenny et al., 1998, Van Dalfsen et al., 2000) and biomass can be restored to pre-dredge levels within two-four years (Kenny et al., 1998, Boyd et al., 2006, Boyd et al., 2005).

Water quality parameters can also be affected both during and after extraction activities. These include: water chemistry; increased suspended sediment concentrations; turbidity; the lowering of dissolved oxygen levels and siltation (OSPAR, 2010a).

Impacts

- **Dredging techniques** locally depletes the benthic community rather than cause uniform reduction. Left behind are potentially colonizing species (Newell et al., 1998)
- **Seabed recovery** after intensive or protracted periods of activity can take longer in low-energy systems or not at all depending on local conditions

(Foden et al., 2009, Van Dalfsen et al., 2000, Robinson et al., 2005, Sutton and Boyd, 2009, Sutton, 2008)

- **Foodweb structures** could be affected from the base upwards due to seabed instability and water quality issues (OSPAR, 2010a)
- **Noise** levels generated by extraction are in the lower frequency region similar to those of large tankers or cargo carriers while underway. There is potential to cause harm or distress to passing marine mammals (Lepper et al., 2012)

Likely Trends

No information on likely future trends in aggeregate extraction is available.

Oil and Gas extraction

In 2007, OSPAR region III produced 0.9 million toeq (tonnes of oil equivalents) of oil and 7.2 million toeq of gas (OSPAR, 2010a). This is a relatively low figure compared to the 24.3 million toeq and 31.1 million toeq produced by Region I (Arctic Waters) and 205.4 million toeq and 172.8 million toeq produced by region II (Greater North Sea).

Most oil and gas activity in the Celtic Seas ecoregion occurs in relatively shallow bays in three separate sea areas (Celtic, Irish and Malin Seas) (OSPAR, 2009a).

Four Offshore SEAs have been carried out in Irish waters. These are IOSEA1 in the Slyne/Erris/Donegal area (2006), IOSEA2 in the Porcupine area (2007), IOSEA3 in the Rockall area (2008) and IOSEA4 in the Celtic Sea and Irish Sea area (2011). Offshore exploration licences and leases are issued by the Petroleum Affairs Division (PAD) of the Department of Communications, Energy and Natural Resources (DCENR). As of 30 September 2012 three petroleum leases (the right to produce oil) had been issued. Two of these are in the Celtic Sea off the coast of Co. Cork (Kinsale/Ballycotton and Seven Heads) and the third is the Corrib field off the coast of Co. Mayo. Twenty three exploration licences; 19 licensing options and 6 prospecting licences are also current (figure 3.1.3.2).

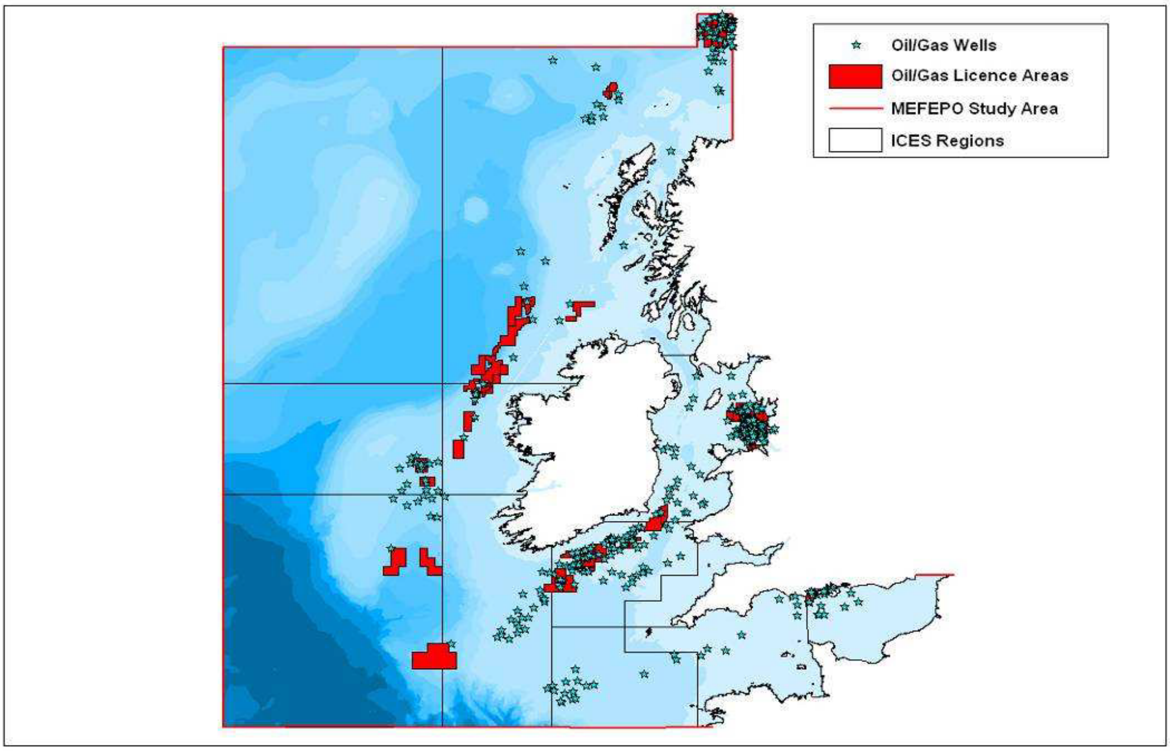


Figure 3.1.3.2. Oil and gas exploration and extraction in the Celtic Seas Ecoregion (Nolan et al 2011)

Pressures and State

The initial seismic survey phase involves the rapid release of compressed air from single or multiple air-guns downwards into the seabed to produce an impulsive signal. This activity, which can extend over vast areas over prolonged periods of time, is thought to affect different fish and mammal species in different ways (Richardson et al., 1998, McCauley et al., 2000, Gordon et al., 2003, Southall et al., 2007, Weilgart, 2007, Boyd et al., 2008, Ainslie et al., 2009).

During the construction phase the seabed is physically disturbed when pipelines, cables and subsea structures and platforms are put in place. During the production phase heavy metals, aromatic hydrocarbons, alkyl phenols, radionuclides, corrosion inhibitors and demulsifiers from discharges of produced waters (water found in reservoirs along with the oil or gas) and emissions of volatile organic compounds such as methane, sulphur dioxide, nitrogen oxides and carbon dioxide can be released into the water and the atmosphere. Drilling processes also use a range of water-based and organic-phase fluids that contain a range of chemicals. These are generally recycled and only disposed of when spent (OSPAR, 2010a).

Accidental spills are also a possibility at any stage of the project life cycle. These can arise from a number of sources including pipeline and valve leaks, broken hoses, during the filling or emptying of tanks or during transportation. Section x discusses the number and impacts of oil spills in the OSPAR and Irish Sea region.

Impacts

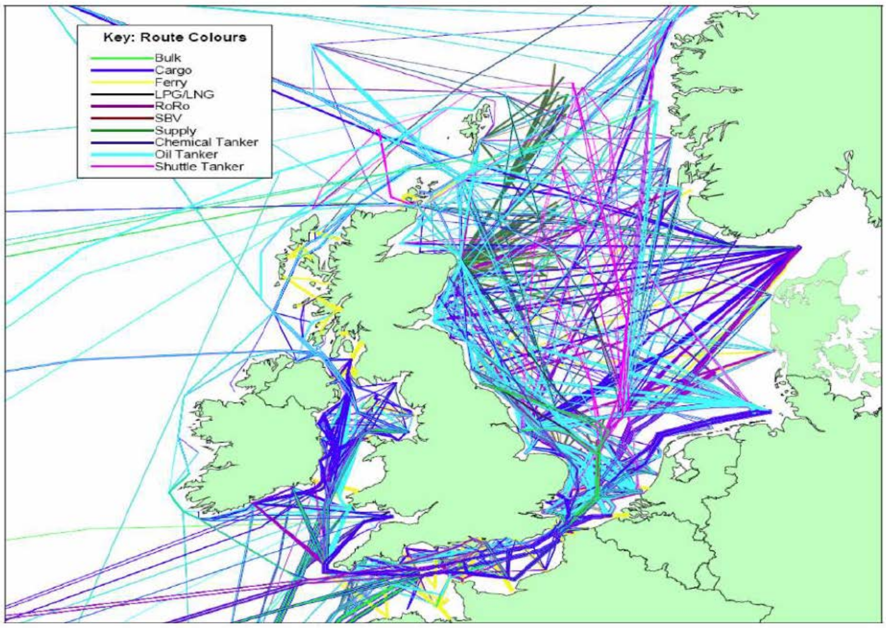
- It is difficult to measure animal behavioral responses to construction and operational noise. Observations in baleen whales, odontocetes and pinnipeds include; fright, avoidance and changes to vocalization patterns. In some cases these have occurred at ranges of tens and hundreds of kilometers from the source (Gordon et al., 2003)
- There is evidence that new hard substrata created by pipelines and platform legs not only provides a shelter for fish and mobile organisms (OSPAR, 2010a) but subpopulations of reef-forming coral *Lophelia pertusa* have been noted attached North Sea installations (Roberts et al., 2003, Gass and Roberts, 2006)
- Studies in the Northeast Atlantic region show that killer whales (McHugh et al., 2007), cetaceans (Berrow et al., 1998, Berrow et al., 2002, Pierce et al., 2008), seals (de Swart et al., 1996, Ross et al., 1996), shellfish (Neff et al., 1976, Durell et al., 2006), fish (Cronin et al., 1998, Neff, 2002) and seabirds (Walker, 1990, Monteiro and Furness, 1997, Borgå et al., 2005) are impacted by the bioaccumulation of toxic substances
- Water-based and organic-phase fluids can bind to rock and be released into the sea. Benthic organisms can respond to exposure to these fluids and oil on drill cuttings through impaired growth and reproduction and increased mortalities (Daan et al., 1994, Cranford et al., 1999)

Likely Trends

Oil and gas exploration continues in the Celtic Seas ecoregion. New substantial finds have been made off southern Ireland, and these will also be expected to come on stream in the next few years. The outlook is likely for more oil and gas extraction in this ecoregion.

3.1.4 Shipping

A significant number of freight and passenger traffic routes cross and pass through the Celtic Seas region (figure 3.1.4.1). Traffic is more marked and widespread in the eastern sector.



(Source: OSPAR, 2009)

Figure 3.1.4.1. Freight and passenger routes in the Celtic Sea region. Passenger routes are highlighted in yellow. All others are associated with cargo/commercial activities (Nolan et al., 2011)

Pressures and State

OSPAR's 2010 Quality Status Report (QSR) summarizes the potential hazards associated with marine traffic as follows:

- **Water pollution caused by the release of oil** from incidental, operational or illegal discharges. Since 2000 there has been an overall decrease in the number of oil spills in the OSPAR region. Figure x shows the location and estimated volumes of oil spilt in OSPAR regions II and III in 2008. The last significant spill in the Celtic Sea was in 2009 when a refuelling Russian warship lost 522 tonnes of oil which drifted in three separate slicks over an area of 40 sq km (Times, 2009).

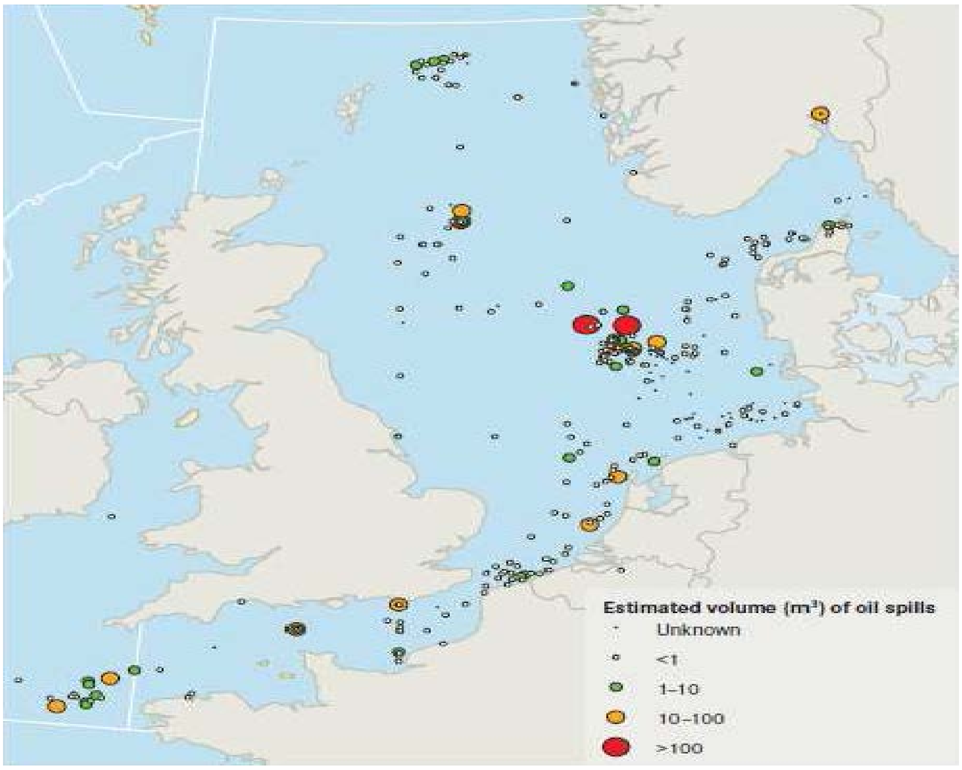


Figure 3.1.4.2. Location and estimated volume of oil spills in 2008. Smallest circle = unknown, clear circle = <1 m^3, green circle = 1-10 m^3, yellow circle = 10-100 m^3 and red circle = >100 m^3 (OSPAR, 2010a)

- **Emissions of nitrogen and sulphur oxides (NO_x and SO_x) and particulate matter** from engine exhaust gases and cargo tanks can be carried by atmospheric conditions long distances from the initial source of discharge. OSPAR found that most emissions in EU sea areas are from cargo ships over 500 gross registered tonnage. Approximately 45% of all emissions are from EU-flagged vessels and about 20% are emitted from within 12 miles of the coast. Models predict that by 2020 emissions from international shipping in all EU seas will increase from their 2000 levels by 40% (3,200 kt particulate matter), 45% (4,800 t NO_x) and 55% (400 kt SO_x)
- **Release of toxic chemicals** used in antifouling paints and anodes. Following the global ban on tributyltin (TBT) in antifouling systems by the International Maritime Organization (IMO) in 2008, the release of the substance is expected to decline/cease. However it has been noted that discharges of TBT substitutes such as copper and Irgarol are expected to increase
- **Discharges and disposal of wastes from ships including sewage**. The effects of raw sewage on water quality in open seas are thought to be minimal as bacterial action breaks down toxic substances however discharges in coastal areas could be problematic
- **Loss of vessels and cargo** can cause surface pollution and have submarine impacts
- **Dredging and sediment dumping** activity to clear shipping channels temporarily or permanently, depending on the intensity and frequency of the activity, removes seabed habitats and their associated biota

- **The risk of non-indigenous species transfers/introductions** is related to the amount of ballast water, the frequency of traffic and environmental conditions where the water originated
- **Introduced noise** can affect migrating species. It is estimated that there has been an approximate doubly (3 bB increase) in background noise in many coastal zones due to shipping movements
- **Collisions** between commercial vessels/leisure craft and marine mammals have been reported in busy areas
- **Marine litter** is primarily found at sea - approximately 70% sinks to the seabed, 15% floats and the remainder is found on land (OSPAR, 2009c) . Debris can vary in size from the microscopic to large fragments and much of it is durable and persistent e.g. plastics (Thompson et al., 2004)

Impacts

Impacts to the physical and biological environment from shipping activities are difficult to quantify as the quantity, type, duration and location of the pollution incident will vary.

- **Dredged sediment** can cause disturbance to benthic habitats (see section x). There is also anecdotal evidence that sediment removed from the Boyne Estuary, Co. Louth is being dumped on an adjacent SPA
- **Introduced noise** can affect fish through behavioural responses, audibility, masking (i.e. obscuring of sounds generally at similar frequencies), hearing loss, discomfort or injury (Gill et al., 2012). Captive North Sea fish species have been shown to respond differently to anthropogenic noise in frequencies ranging from 0.1–64 kHz. Seven out of eight tested species (herring being the exception) reacted to sounds below 2 kHz (Kastelein et al., 2008)
- **Litter** poses a threat to marine mammals as they can become entangled, ingest or adsorb toxic substances such as polychlorinated biphenyls (Derraik, 2002). It is estimated that plastic litter kills 100,000 marine mammals and turtles and 1 million seabirds worldwide each year (OSPAR, 2009c)

Likely Trends

Based on an EU study (Sessa and Ennei 2009) European shipping has increased by 37% in the 12 years 1995-2007. This trend may be expected to continue, although modified by the current fiscal situation.

3.2 Pressure

Data should preferably be presented in the form of maps showing frequency, density, or trends over time in the activity.

Potential factors to include

Effects of eutrophication, estimated as distribution and frequency of algal blooms and oxygen deficiency

Fishing activities, indicated by estimates of temporal trends and/or spatial patterns in catches and bycatches in relation to different gear types

Frequency of shipping and oil accidents

References:

Description of narrative:

Ensure that if there are restrictions to data interpretation, this should be mentioned in connection to the graphs.

3.2.1 Eutrophication

Based on the OSPAR 2008 Report on Eutrophication Status of the OSPAR Maritime Area, the Celtic Seas ecoregion (OSPAR region III) is generally a non problem area for eutrophication, except in inshore areas. The overview is presented in figure 3.2.1.1, and the situation for coastal areas in Ireland is presented in figure 3.2.1.2

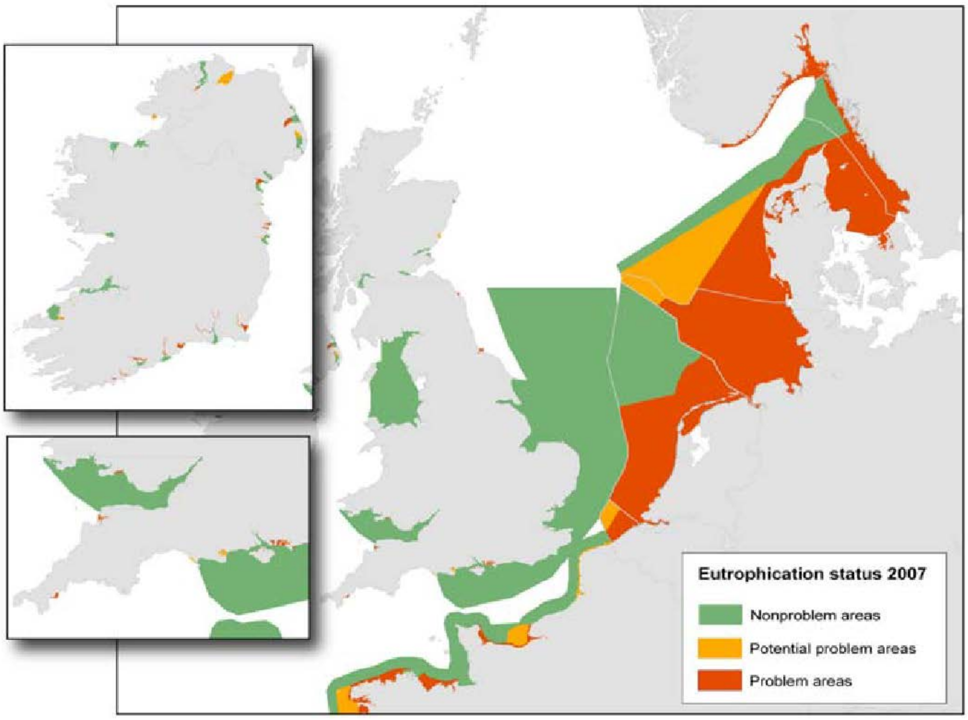


Figure 3.2.1.1. Eutrophication status of the Greater North Sea (Region II) and the Celtic

Seas (Region III) identified in the second application of the Comprehensive

Procedure in terms of problem areas, potential problem aeras and non-problem

areas. Taken from OSPAR 2008

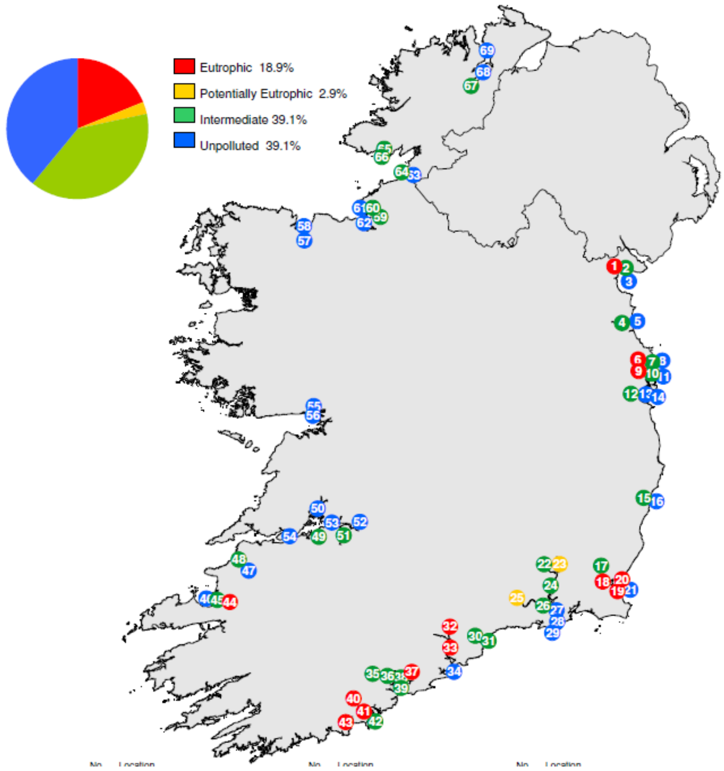


Figure 3.2.1.2. Estuarine and coastal water quality 2002-2006.

3.2.2 Fishing

High quality datasets are available for VMS based fishing activity in the UK and Irish EEZs. An example of the type of output is presented in Figure 3.2.2.1.

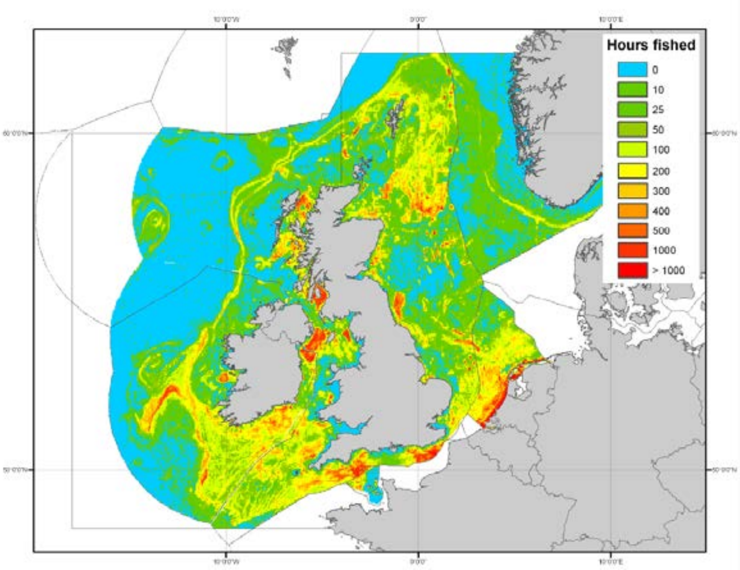


Figure 3.2.2.1. Illustrative example fishing activity plot based on VMS data. Calculated based on 2006 VMS data from submitting nations for all mobile bottom gears combined. From Le Quesne et al 2010 MEFEPO North Sea GES report. See Le Quesne et al 2010 for description of methods. [Le Quesne et al. 2010 Assessing the impact of fishing on the Marine Strategy Framework Directive objectives for Good Environmental Status. MEFEPO FP7 project WP2 report. www.liv.ac.uk/mefepo/.]

VMS combined with information on the gear used and the seabed habitat, can allow an indication of the direct impact of gears on the seabed, as illustrated in the figure below.

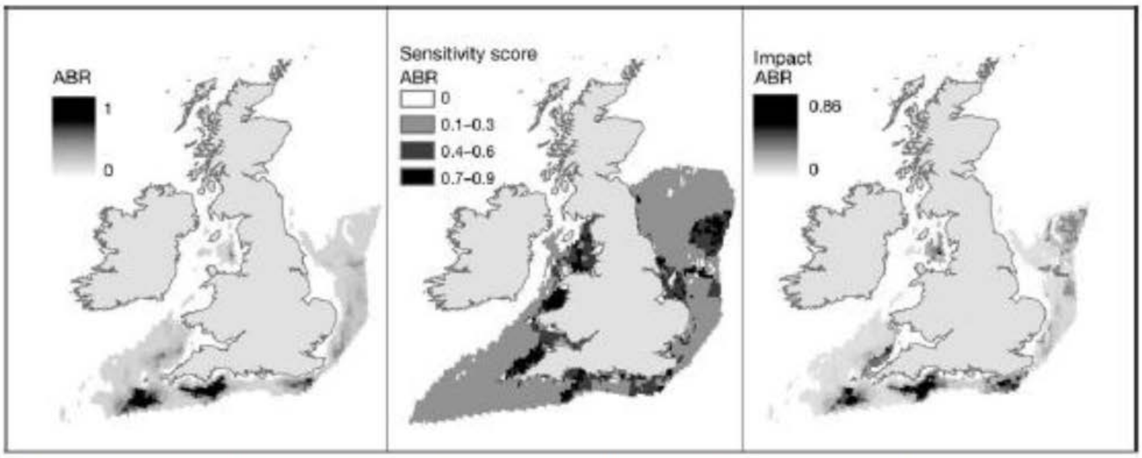


Fig. 3. Left: Abrasion (ABR) pressure map based on processed Vessel Monitoring System (VMS) data reflecting the average (2001 to 2006) fishing pressure of beam trawls, otter trawls and scallop dredgers (see Stelzenmüller et al. 2008); mid: marine landscape categories with associated measure of sensitivity (derived from Defra 2007) to abrasion; right: estimated impact of abrasion

This approach however requires good quality habitat data, and this not yet available for entire area, with significant gaps in the Celtic Sea itself, and the west of Ireland (Figure 3.2.2.3.)

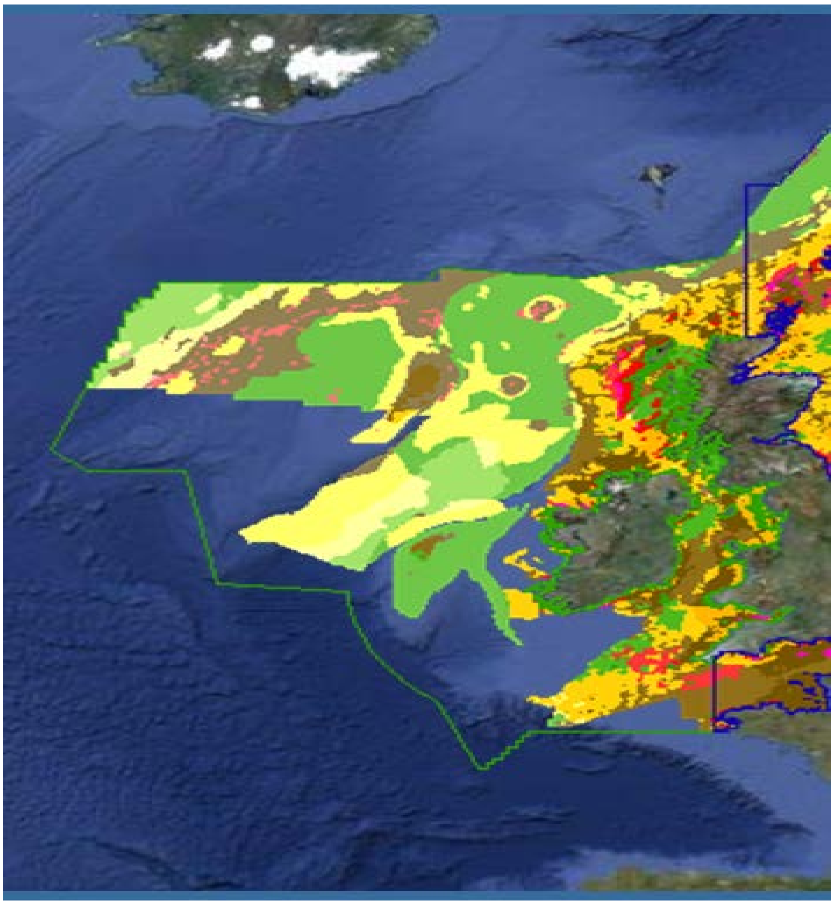


Figure 3.2.2.3.Simplified Seabed classifications taken from EMODNET.

VMS can also be used to provide information on the untrawled seabed as a proportion of the total – one of the seabed integrity indicators for the MSFD (Le Quesne in prep) an example of this is presented in table 3.2.2.1.

Table 3.2.2.1: Proportion of area not trawled (ANT) for the Celtic Sea MSFD Ecoregion by depth band as a proportion of the area for which data are available. The percentage of the area for which data are available is shown in parenthesess. Based on 2007 VMS data for all mobile bottom gears combined. Calculated according to Le Quesne et al in prep. [Source: Le Quesne et al in prep].

Depth Band (m)	ANT
0-20	0.74 (84)
20-50	0.68 (94)
50-80	0.47 (94)
80-130	0.51 (88)
130-200	0.58 (90)

3.2.3 Endangered Species

Cetaceans

Based on the work of ICES 2011, there is some scope for concern about the scale of cetacean bycatch in some fisheries in the Celtic Sea Ecoregion (Table 3.2.3.1).

Management region	Possible scale of annual bycatch	1.7%	Comment (most important caveats)	Summary
Harbour porpoise – static nets				
Atlantic (North)	1520–19 634 animals per year 2009: UK 791; France >300; Spain ~300	2617	High figure based on one sample off Ireland; incomplete fleet sampling in all member states.	O
Common dolphin (+ striped dolphin) – static nets				
Atlantic	1111 (or 1778 if all fleets extrapolated at UK rate) excl Iberia	5841	Sum of French days x bycatch rate, UK days x bycatch rate, and Spain days x bycatch rate, with the remainder of the fleet extrapolated at the UK rate.	O
Common dolphin (+ striped dolphin) – for bass/tuna pair trawls				
Atlantic	1253	5841	For 2009, most recent year of estimates, but it has been higher.	O
Common dolphin (+ striped dolphin) – other pelagic trawls				
Atlantic	0-30	5841	Very low bycatch rate, but observer coverage is incomplete.	+

Table 3.2.3.1: Possible scale of bycatches of cetaceans in static nets and pelagic trawls, with comparison with 1.7% limit and caveats. Summary key: red circle icon = recommend immediate mitigation measures; orange circle icon = enhanced short/medium term observation to decide appropriate action; green circle icon = no action required at present beyond background observation. Atlantic region covers ICES areas VI, VII, VIIIa,b,c,d,e, IX. Atlantic (North) covers ICES areas VI, VII, VIIIa,b, Atlantic (South) covers ICES areas VIIIc,d,e, XI. [Source: ICES 2011 Advice Book 1, Section 1.5.1.4]

Two more recent studies (Boyd et al 2011, McCarthy et al 2012), showed zero bycatch in both pelagic and set-net fisheries in Irish waters. However, a study of strandings in Cornwall UK, suggested 61% of stranded cetaceans had died as a result of bycatch events. Northridge et al (2007) indicate that the main bycatch in this ecoregion is for both harbour porpoise and common dolhin in the tanglenet and gillnet fisheries, as well as in the bass pair trawl fishery for common dolphin. They further conclude that in no case in the ecoregion does the bycatch exceed the 1.7% reference level.

Seabirds

At least 25 species of seabird are reported in good numbers in the ecoregion, and these are presented in table 3.2.3.1. Data are derived from Mackey and Giménez, (2004) and Mackey et al., (2004). Three other species are reported as rare sightings only Great Northern Diver (*Gavia immer*), Mediterranean Shearwater (*Puffinus yelkouan mauretanicus*), and Wilson's Storm-petrel (*Oceanites oceanicus*).

Table 3.2.3.1. Species and estimated numbers of seabirds in the Celtic Seas Ecoregion.

Common Name	Latin Name	Uncorrected Total
Northern Fulmar	*Fulmarus glacialis*	357,661
Great Shearwater	*Puffinus gravis*	5,654
Sooty Shearwater	*Puffinus griseus*	2,730
Manx Shearwater	*Puffinus puffinus*	187,354
European Storm-petrel	*Hydrobates pelagicus*	23,460
Leach's Storm-petrel	*Oceanodroma leucorhoa*	1,232
Northern Gannet	*Morus bassanus*	196,334
Great Cormorant	*Phalacrocorax carbo*	1,812
European Shag	*Phalacrocorax aristotelis*	7,046
Pomarine Skua	*Stercorarius pomarinus*	557
Arctic Skua	*Stercorarius parasiticus*	833
Long-tailed Skua	*Stercorarius longicaudus*	380
Great Skua	*Stercorarius skua*	3,785
Black-headed Gull	*Larus ridibundus*	11,561
Mew Gull	*Larus canus*	8,764
Lesser Black-backed Gull	*Larus fuscus*	36,721
Herring Gull	*Larus argentatus*	56,019
Great Blacked-backed Gull	*Larus marinus*	24,360
Black-legged Kittiwake	*Rissa tridactyla*	126,324
Common Tern	*Sterna hirundo*	1,747
Arctic Tern	*Sterna paradisaea*	1,233
Common Guillemot	*Uria aalge*	136,934
Razorbill	*Alca torda*	34,015
Black Guillemot	*Cepphus grylle*	1,132
Atlantic Puffin	*Fratercula arctica*	28,504

Other Species

As highlighted in the OSPAR QSR 2010, data for seals in this ecoregion are insufficient to establish ternds in population, or accurate population estimates. Additionally seal bycatch data are poorly quantified. Several studies on this are ongoing and are expected to be complete by the end of 2013.

Marine Reptiles are relatively rare in these wtares, four species have been identified since 1990: the leatherback turtle (*Dermochelys coriacea*), green turtle (*Chelonia mydas*), Kemp's ridley turtle (*Lepidochelys kempii*) and loggerhead turtle (*Caretta caretta*) (Penrose and Gander, 2012). Sightings and strandings are shown in figure 3.2.3.1.

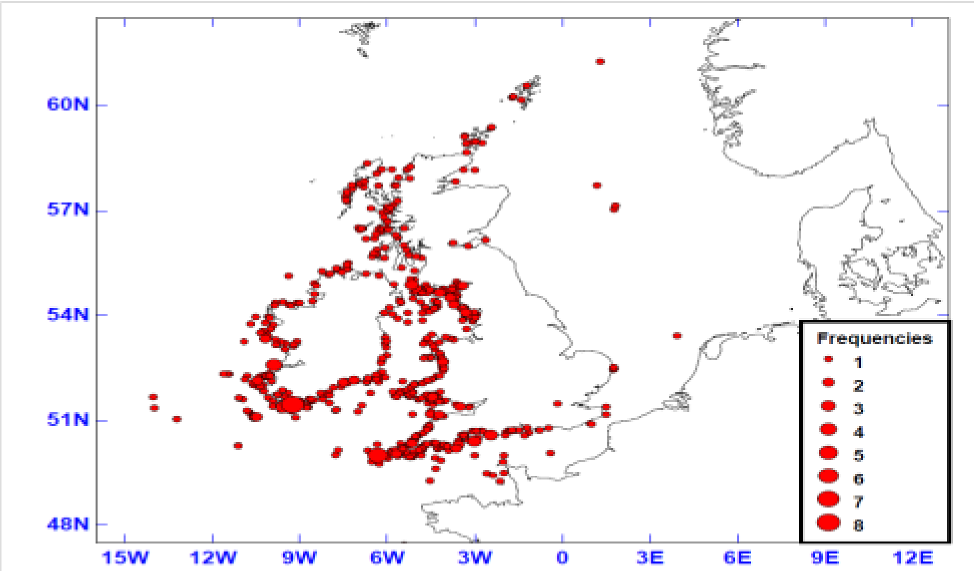


Figure 3.2.3.1. All turtle species, sightings and strandings 2001-2011

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Sessa C and Enei R (2009) EU transport demand: Trends and drivers ISIS, paper produced as part of contract

ENV.C.3/SER/2008/0053 between European Commission Directorate-General Environment and AEA Technology plc; see www.eutransportghg2050.eu

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