Supplementary Material

A Review characterizing 25 ecosystem challenges to be addressed by an Ecosystem Approach to Fisheries Management in Europe

Francois Bastardie,1,\*,#, Elliot J. Brown,1,\*,#, Eider Andonegi2, Robert Arthur3, Esther Beukhof4, Jochen Depestele5, Ralf Döring6, Ole Ritzau Eigaard1, Isabel García-Barón2, Marcos Llope7, Hugo Mendes8, GerJan Piet4, David Reid9

1National Institute of Aquatic Resources, Technical University of Denmark, 2800 Kgs. Lyngby, Denmark

2AZTI, Marine Research Division, Basque Research and Technology Alliance (BRTA). Txatxarramendi ugartea z/g, 48395, Sukarrieta (Basque Country, Spain)

3MRAG Ltd, 18 Queen Street, London, W1J 5PN, UK

4Wageningen Marine Research, Wageningen University & Research, P.O. Box 68, 1970 AB IJmuiden, Netherlands

5ILVO, Research Institute for agriculture, fisheries and food, Ankerstraat, 1 8400 Oostende, Belgium

6Institute of Sea Fisheries, Herwigstraße 31, 27572 Bremerhaven, Germany

7IEO Spanish Institute of Oceanography, Madrid, Spain

8Division of Modelling and Management of Fishery Resources, Portuguese Institute for the Ocean and Atmosphere (IPMA), Av. Dr. Alfredo Magalhaes ~ Ramalho, 6, 1495- 165, Algés, Portugal

9Marine Institute, Rinville, Oranmore, Co. Galway, Ireland

Annexe 1. Expert knowledge collection on ecosystem challenges.

**Table 1.1. Guidance for information collected on ecosystem challenges**

|  |  |
| --- | --- |
| Data Collection  | Details  |
| Purpose  | This is a request to all project partners to provide input about locally relevant ecosystem challenges to fisheries. The information collected here will be supplemented by a systematic review being undertaken by DTU Aqua.  |
| Project relevance  | The results of your input will inform ecosystem challenges local fisheries are facing.  |
| Request  | Please fill out the attached table with locally relevant examples of ecosystem challenges linked to specific fisheries One row will be a unique combination of “Fishery”, “Challenge Type”, and “Challenge”. For each fishery, there should be at least three entries, one for each challenge type, but there may be more. Published supporting evidence may come from scientific literature, grey literature or be non-existent (for current challenges not yet studied/published)  |
| Specific guidance  |
| Fishery  | Please find an appropriate scale, which may be based on a target species or a specific mixed fishery in your area. The specificity may vary.  |
| Challenge type  | Three pre-defined challenge types are corresponding to the project application: Fishery effects on the ecosystem, ecosystem effects on the fishery, and social/governance effects on the fishery. These are further described in the example entries provided in the table (the examples are very generic, your responses may be as generic or more specific).  |
| Challenge  | Please identify the general challenge that applies to the selected fishery example.  |
| Issue identified  | Elaborate on the challenge, what causes it and what effects does it produce?  |

**Challenge 1.1: Fish extraction alters exploited stocks' resilience - Box EU Partners Input**

* Mixed demersal trawling fisheries for cod & flatfish in the West Baltic
* Fish stock status: Fishing for cod would further deteriorate the poor stock status of eastern Baltic cod given fishing mortality still too high, e.g., for western Baltic cod.
* Pelagic fisheries for sprat and herring in the Baltic
* Fishing for especially sprat in the southern Baltic may impact food availability for cod and thereby its growth and condition. There is a possible large misreporting issue between sprat and herring in the Baltic when landed for industrial purposes. This would lead to a wrong stock status on the two stocks.
* Salmon fisheries of mixed stocks (both in good and poor conditions)
* The threat of extinction of Baltic salmon stocks with poor status: Genetic identification of baltic salmon shows that there are specific stocks for each of the salmon river. In general salmon stocks from the north of Baltic Sea are productive and in good condition, while eastern and southern stocks are in poor condition. Fish representing both types of baltic salmon stocks are gathering in the southern Baltic for feeding and are exploited there.
* longlines, eel fishery, Western Baltic Sea
* Management of anthropogenic impacts at all life stages, data, and coordination challenge. 2017: historically low levels in eels in the Baltic Sea and EC proposed ban for commercial and recreational eel fishery across life stages of the eel. in 2008 and in 2014, the eel was listed in the IUCN Red List as a critically endangered species.
* Purse seiner targeting small pelagic fishes in the Bay of Biscay
* The decline of the sardine stocks, both in the Bay of Biscay and the Iberian Waters, this last in very poor body condition for the last 3-4 years.
* French Demersal trawlers in the Bay of Biscay
* Fishing pressure: Despite improvements in selectivity, trawlers targeting **Nephrops** are still catching small hakes, sometimes below the Minimum Conservation Reference Size.

**Challenge 1.1: Fish extraction alters exploited stocks' resilience - Box ICES reports**

* WGNSSK: Nephrops in the North Sea. Different sexes have a different catchability (due to behavioural differences) and hence fishing pressure. Therefore, stock-wide measures of abundance and production are not applicable. The assessment for this stock (or the functional units within) utilise combinations of sex-specific indicators to come to an overall mean-stock indicator. These are validated against sex-specific stock-recruit ratios to ensure one sex isn’t being overexploited. If the validation metrics show one sex under too much pressure, more conservative sex-specific indices of F are used.
* WGBIE: Seabass in 8a & b: Discards of juveniles are known to take place but are not fully quantified.
* WGWIDE: North Sea horse mackerel and western Horse Mackerel. The fishery for small pelagics in the western Skagerrak catches horse mackerel from different stocks in different times of the year. The assessment for this stock splits catches temporally, for this area, and assigns them to their respective stocks and this practice is considered mature.
* WGDEEP: Roundnose grenadier in 3a. A short fishery over-exploited this isolated stock. Recovery is dependent on a strong recruitment event, which is unlikely given the small stock size and was unpredictable during times of larger stock size.

**Challenge 1.2: Fishing results in loss of biodiversity (bycatch and habitat degradation) -Box EU Partners Input**

* Industrial Fisheries in the North Sea for sandeel and sprat
* Sprat and sandeel are mainly fished with large bottom contacting trawls. In general, relatively light gear components are deployed on sediments with relatively low sensitivity to physical disturbance, and the benthic impact is assessed to be limited. Bycatch is limited in the sandeel fishery, although an unknown component of a non-targeted sandeel species is presumably being caught in management area SA2r. There is, at times when herring stocks are in poor shape, a potential herring bycatch problem in the sprat fishery (bycatches are therefore monitored). Sprat and sandeel are important prey to a range of marine predators (fish, birds, and mammals). Nevertheless, local requirements of prey biomasses to sustain ecosystem services is unspecified.
* The small-meshed fishery for Norway pout in the Northern North Sea
* Bycatches: Several species (mainly herring and whiting) are being caught as bycatches in the Norway pout fishery.
* Benthic impacts: The fishery deploys large bottom contacting trawls with moderately heavy gear components, often on sediments with relatively high sensitivity to physical disturbance, and the benthic impact is assessed to be at an intermediate level. Norway pout is important prey to a range of marine predators, but local requirements of prey biomasses to sustain ecosystem services are unspecified.
* Mixed demersal towed gear fisheries in the North Sea
* litter/ghost nets: Mending fishing gear at sea result in net cut-offs which are often discarded and subsequently can cause entanglement of fish, mammals and seabirds. The use of dolly ropes on, e.g. beam trawl leads to rope fragments which are ingested by filter or benthic feeders.
* Physical disturbance: Bottom fishing impacts the habitat suitability for resident ecosystems (by creating possible smoothing of the seabed, etc.).
* Mixed demersal static gear fisheries in the North Sea
* Bycatch/ghost fishing: Marine mammals and seabirds are prone to bycatch in passive gear and ghost nets. Ghost nets impact all active fish species in a size range matching the gear mesh size.
* Demersal trawling for Pandalus Borealis in Skaggerak and Norwegian Deep (3.a and 4.a East)
* Catch and by-catch: A number of deep-sea species such as roundnose grenadier, rabbitfish, and sharks are frequently caught in shrimp trawls in the deeper parts of Skagerrak and the Norwegian Deep. No quantitative data on this mainly discarded catch are available, and the impact on stocks is difficult to assess. The fishery also has by-catches of 10–23% (by weight) of commercially valuable demersal fish species, which are legal to land if quotas allow. The target species is important prey to a range of marine predators in Skagerrak, and the current assessment model carries an assumption of an average M of 0.75 for the stock. The local requirements of prey biomasses to sustain ecosystem services are unspecified
* Physical disturbance: Northern shrimp are typically fished with medium-sized demersal otter trawls (twin trawls) with relatively heavy gear components. Trawling takes place with high annual intensity and mostly in deep water, soft-bottom sediments, which have relatively high sensitivity to physical disturbance. Consequently, the benthic impact is assessed to be at a high level.
* Mixed demersal trawling fisheries for cod & flatfish in the West Baltic
* Physical disturbance: Bottom fishing impacts the habitat suitability for resident ecosystems (by creating possible smoothing of the seabed, etc.)
* Mixed demersal trawling fisheries for cod & flatfish in the Central Baltic
* Bottom fishing impacts the habitat suitability for resident ecosystems (by creating possible smoothing of the seabed, etc.)
* Pelagic trawling fisheries in the Central Baltic Sea, Or Small scale fishery in Latvian coastal waters
* Bycatch of protected species such as the cetaceans
* Mixed demersal trawling fisheries for cod, Nephrops & flatfish
North Sea
* Physical disturbance: Bottom fishing impacts seabed habitat and associated species but more quantitative approaches required
* Pelagic trawl fisheries in the North Sea (ICES area 4)
* Seabirds: Reduction in breeding bird success potentially through a reduction in prey availability and possibly initiated by commercial fisheries (past and present) in combination with climate change.
* Bycatch: Bycatch of Protected, Endangered, or Threatened Species (PETS) of seabird
* All UK pelagic and demersal trawl fisheries (OTB) plus
the bottom set gill nets (GNS) and entangling nets (GTR)
* Bycatch of Protected, Endangered, or Threatened Species (PETS) and unwanted species
* Purse seine (anchovy and others) fishery in the Gulf of Cadiz
* Seabirds: Potential accidental bycatch of marine birds, particularly important when fishing overlaps with the GoC Birds Special Protection Area (SPA)
* Slipping: Slipping is a practice reported in the Gulf of Cadiz (pers. comm.), the extent to which it affects the survival of those non-target fish species depends on several factors. Particularly important now due to the current situation of the sardine stock
* Striped Venus clam (Chamelea gallina) fishery in the Gulf of Cadiz
* This fishery uses a hydraulic dredge that has a strong impact on the whole benthic community
* Mixed beam trawl fisheries for flatfish in Central North Sea, Or Beam trawl fisheries for shrimp in coastal (Eastern) the North Sea, or Nephrops (otter) trawling
* Physical disturbance: Bottom fishing impacts the physical sediment structure of the habitats by smoothing and resuspending sediments
* Benthic Biomass: Benthic community disturbance (structure and function) with effects on the ecosystem: biodiversity, seafloor integrity
* Fish bycatch: non-target epibenthic and fish community (bycatch and mortality in the towed path) with effects on the ecosystem biodiversity
* Fish stocks: sustainable management of fish populations, high discard levels of various species, inbreeding in overexploited stocks (e.g., Plaice in the North Sea)
* Plastic: Wearing and tearing of beam trawl, particularly the loss of chafing gear
* Chemical: The former use of TBT (tributyltin) has been eradicated, but it is unclear what alternatives are being used and what their effects are
* Climate: high fuel consumption
* Mixed demersal trawling fisheries for whitefish and Nephrops in the Celtic Sea
* Abrasion by trawl gears

Impact on the benthic community in terms of Relative Benthic Status (RBS) (WGFBIT)

* Demersal trawl fishery for Nephrops and fish (3a and 4)
* Bottom fishing affects the seafloor affecting the structure and function of benthic communities through e.g. direct impact and smothering, and changes in turbidity and habitat complexity.
* Sensitive species: The limited selectivity of fine-meshed trawls leads to the possible bycatch of recruits of overexploited species (e.g., cod), and of sensitive and endangered species (e.g. elasmobranchs)
* Fisheries with passive gears in 3a (creels, traps gillnets)
* Bycatch mammals and sea birds: Passive gears and most notable gillnets will bycatch marine mammals and seabirds and cause mortality through drowning.
* beam trawl (TBB), North Sea, the shrimp fishery
* Overfishing and discards: increased fishing effort has led to growth overfishing of brown shrimp; Small mesh sizes again led to catch of non-target species; seasonally variable, shrimp landings entailed about 70% of small shrimp bycatch and others. since 1970s shrimp fisheries were non-regulated; the fishery has no quota (no stock assessments take place) but has implemented an industry-led management plan in the context of MSC certification, however, it has not been in operation for a long time, and so information and evidence to support and demonstrate its effectiveness is limited at present
* Physical disturbance: Beam trawls are known for their disturbance of the benthic communities on the seafloor (ICES 2014\_ Germany advice Crangon crangon)
* Beam trawl, mesh 33-70mm, mussel fishery, Eastern North Sea (German coast)
* physical disturbance and removal of mussels as the link between primary producers and the higher trophic levels: blue mussel production is based on bottom-culture techniques; seed mussels are obtained from wild beds in the coastal sea and mussels are collected with dredges from natural intertidal and subtidal habitats and transferred to licensed culture plots in the Wadden Sea (Buck et al. 2010)
* Mixed plaice and sole fishery, Central and the southern North Sea; Plaice main target species
* very high discards: Substantial discarding continues (estimated unwanted catch for 2018 is 7649 tonnes in Subarea 4 and Division 3.a, i.e. 8.7% of the total catch)
* physical disturbance (bottom impact)
* Beam trawl Plaice fishery, Central North Sea
* Physical disruption of the seabed through contact of the gear components with the sediment and the resuspension of sediment into the water column; they have been shown to impact the benthic environment by modifying habitats, community structure, and geochemical processes; (i) immediate biological effects such as direct damage and mortality to the benthos, (ii) geochemical effects such as the release of nutrients or contaminated sediments, and (iii) physical effects which can be categorized as being either geotechnical or hydrodynamic; beam trawlers contribute extensively to the physical impact on the seabed in the southern North Sea and can affect benthic invertebrate and demersal ﬁsh communities, depending on beam trawl weight, towing speed, and sediment type.
* high discard rates: In 2018, 52% of the total catch in Subarea 4 and 19% in Subdivision 20 was discarded
* German Otter trawl in the North Sea for Plaice and Nephrops, Plaice, or Saithe fishery
* Physical disturbance and benthos depletion: Bottom trawling will reduce the biomass and biodiversity of the benthic ecosystem, and may reduce the complexity of seabed habitats and affect the functioning and productivity of the benthic ecosystem through a progression of state changes. The ecosystem effects of bottom trawling will be determined by the type of gear deployed, the type of seabed, direct effects of the passage of a trawl, the footprint of the trawl and the trawling frequency and the sensitivity of the seabed and benthic ecosystem. Otter trawls and seines mainly sweep the surface of the seabed, whereas shellﬁsh or ﬂatﬁsh dredges and tickler chain beam trawls will penetrate deeper into the sediment.
* Fish bycatch: Bottom trawl ﬁsheries may have a negative eﬀect on the condition of some of their target species, but not others, by reducing the abundance of their benthic prey
* German demersal seine, mesh >120mm, saithe fishery, cod
* bycatch of sensitive species (e.g. ray): data from observers on board in 2013-2017 showed over 50 different non-target species in the saithe trawl catches
* NLD Trawl fishery
* Physical disturbance: Bottom fishing adverse effect on seabed habitats and additional mortality to invertebrate animals. Pulse trawling might have a smaller effect compared with traditional beam trawl.
* Ghost fishing: Abandoned, lost or discarded fishing gear may continue to catch fish, invertebrates and marine mammals. Entangled animals may die of starvations, wounds, infections or lack of oxygen (mammals). Lost nets contribute to plastic litter in the ocean.
* Bycatch: Beam trawl fishery have incidental bycatch of protected species including mammals, birds, turtles and rare fish species. Bottom trawl and seines fishery have unwanted catch which can be landed and/or discarded
* Unwanted catch: Beam trawl fishery have unwanted catch which can be landed and/or discarded
* Mixed demersal trawling fisheries operating in ICES divisions VIII and VII
* Seabirds: LO creates a food shortage for scavenging seabirds. The landing obligation in EU waters will likely cause a substantial increase in bycatch rates in longliners, at least in the short-term, due to birds switching from trawlers to longliners
* Bycatch: Bycatch of cetaceans, mainly Short-beaked common dolphin *Delphinus delphi*s also Bottlenose dolphin *Tursiops truncatus* and Stripped dolphin *Stenella coeruleoalba*
* Gillnetters and Trammel nets operating in the BoB & Iberian Waters ecoregion
* Bycatch of cetaceans and seabirds. Most affected cetacean species: Short-beaked common dolphin *Delphinus delphis* and Harbour porpoise *Phocoena phocoena*
* Longlines targeting demersal species in the Bay of Biscay
	+ Biomass loss on side ecosystem components: seabirds
* Portuguese demersal bottom otter trawl fish fishery
* Discards: The markets (volume vs commercial value) drive the discarding of the main discarded species, e.g. blue whiting, chub mackerel and blue jack mackerel, MLS and TAC (Regulatory reasons) constituting additional important motives for discarding, e.g., European hake
* Bottom fishing impacts the habitat suitability for resident ecosystems
* Portuguese crustacean bottom otter trawl fishery
* discard practices of commercially valuable species in this fishery are finfish by-catch limits of the crustacean fishery (blue whiting, horse mackerel and jack mackerel), the relative availability and commercial value of each by-catch species within total by-catch (low commercial values when compared to other by-catch), minimum landing sizes (e.g. most hake discarded is below MLS) and quotas (e.g. anglerfish and hake). Several species are discarded for economic restrictions (low or null commercial value for species and/or with no immediate market)
* Bottom fishing impacts deep-sea corals and sponges in areas and habitat suitability for resident ecosystems
* Portuguese demersal longline fishery in the Azores
* Discards: Deep-water sharks are common discarded species although in smaller quantities (mainland and Azores)
* Keystone species: Cold-Water-Corals and charismatic species can also be affected
* Portuguese Gill and trammel nets for demersal fish
* Trammel nets may have an increased effect on bycatch of cold-water corals;
* Considerable ghost nets’ effective fishing lifetime is 10–11 months in the rocky bottom and 8 months in the sandy bottom;
* Elasmobranch species (rays, skates and sharks) are commonly discarded;
* Portuguese Purse seiners for Small Pelagic Fishery
* small vessels fishing close to the coast might have a slight impact on the seabed
* Slipping in purse seine fisheries is not really estimated in the present because they are very hard to estimate without information from fishers or observers on board. How can one estimate slipping in purse seine fisheries? What information can be gathered by the industry? How could it be used and incorporated? If slipping is high, our perception of catches might be biased with consequences on the stock size estimates
* Reports of interaction, with occasional bycatch, between cetaceans/seabirds and purse-seiners
* French Hook vessels (U15m) in the Bay of Biscay or North Western Waters
* Incidental catch of birds, notably when lines are set in coastal areas.
* French Net fleets in the Bay of Biscay targeting fish
* Incidental catch of birds and cetaceans, notably when nets are set in coastal areas. Recent cetacean strandings tend to indicate that interactions with net fleets are still significant, which is also confirmed by onboard observations (OBSMER)
* French Demersal trawlers in the Celtic Sea or in the English Channel or North Western Waters
* The latest French Marine Strategy documents (2019) list the impacts of trawling activity on benthic habitat as potential threats for several geomorphological structures (Ridens de Boulogne, Roches Douvres et Fosse centrale de la Manche)
* French Dredgers for shellfish in the English Channel
* Dredgers' interactions with the seabed are considered important pressures
* French Netters in the Bay of Biscay or the English Channel targeting fish
* Incidental catches - diadromous fish: None of the 7 diadromous species monitored for the MSFD are reaching the good ecological status. One of the key pressures listed on these species is the accidental bycatch in coastal and estuarine areas when these species are migrating
* Pots and traps targeting large crustaceans in the English Channel
* Loss of pots is listed as potential pressure on the stocks of large crustaceans

**Challenge 1.2: Fishing results in loss of biodiversity (bycatch and habitat degradation) - Box ICES WGs reports**

* WGCSE: Sole 7a & g. Beam trawling has a significant impact on benthic communities, although this impact can be harder to ascertain in areas with a long history of beam trawl fisheries.
* WGBFAS: Bottom Contacting Gears in the Baltic Sea. Physical seabed disturbance (primarily from otter-trawls targeting demersal and benthic fish) has been shown to reduce benthic faunal diversity and biomass in neighbouring marine and tidally influenced areas. However, the impact of such fishing activity on Baltic Benthos has received little attention.
* WGBIE: Seabass in 8a & b: Discards of juveniles are known to take place but are not fully quantified.

**Challenge 1.3: Fishing alters food-web interactions - Box EU Partners Input**

* Mixed beam trawl fisheries for flatfish in Central North Sea, Or Beam trawl fisheries for shrimp in coastal (Eastern) North Sea, or Nephrops (otter) trawling
* Foodwebs: Bottom fishing impacts the interactions between benthic infauna and epifauna, as well as non-target fish and target fish communities
* Mixed demersal trawling fisheries for whitefish and Nephrops in the Celtic Sea
* Impact on the benthic community in terms of Relative Benthic Status (RBS) (WGFBIT)
* Foodweb: Changes in predator-prey relationships, particularly predator pressure on forage fish species
* Bycatch: Impact of fisheries removals on mammals abundance.
* Mixed demersal trawling fisheries for cod & flatfish in the eastern Baltic (bottom trawl, spawning time)
* by-catch of cod specifically in flounder catches: potential impact on increased fishing mortality of cod, impact on cod recruitment
* Pelagic fisheries with active gears
* The selective removal of forage fish may lead to changes at lower trophic levels through changes in their consumption of plankton as well as changes in their availability as prey for piscivores, marine mammals and seabirds
* Otter, mesh <90mm, Herring and sprat fisheries, Western Baltic Sea
* mostly multi-species interactions: single-species assessments which ignore
the broader ecosystem context and impact
* NLD Trawl fishery
* Community structure change: Removal of the biomass of target species directly or indirectly (through species interactions) affects the abundances of species, thereby altering community structure (e.g. size spectrum, proportional biomass of large fish (large fish indicator), mean trophic level)
* Trophic cascade: Sole, plaice and other benthivorous species including invertebrates are preyed upon by large demersal fish and elasmobranch species and seals. (1) The fishery removes biomass from the ecosystem that may have otherwise been available to these predatory species. (2) The fishery may indirectly affect the plankton and/or benthos community by removing benthivorous fish from the ecosystem, thereby reducing predation of those fish on invertebrates and potentially also affecting recruitment and thus plankton consumption. Some invertebrates may be targeted by fisheries too.
* Mixed demersal trawling fisheries operating in ICES divisions VIII and VII
* Bottom trawling negatively affects the biomass of a number of functional groups as well as the total biomass of the benthic-demersal community
* Trophic: Bottom trawling negatively affects mean trophic level at spatial scales
* Species richness: High fishing pressure affects the condition of some stocks, potentially causing loss of some species, which negatively affects the biodiversity and so the resilience of these ecosystems.
* Portuguese Demersal bottom otter trawl fish fishery
* Foodweb: species interactions generate fluctuating and cyclic population dynamics and nonlinearity in single-species dynamics generates deterministic fluctuations, these are not mutually exclusive hypotheses as all could act together to increase variability. For exploited species, fishing can also vary from year to year and translate. Directly into population variability or could interact with other drivers to enhance fluctuations in fish abundance.
* Portuguese Purse seiners for Small Pelagic Fishery
* SPF (e.g. Sardina pilchardus) are key species in the Portuguese upwelling system, they are forage fish of the main commercial species, and cascading effects on other commercial species and the ecosystem are enhanced under fishing pressure.
* French Pelagic trawl or Seiners targeting small pelagic species in the Bay of Biscay or in the English Channel, or in the North-Western Waters
* Foodweb: Some of the species targeted by this fleet are forage fish for species with higher trophic levels that may be targeted by other fishing fleets (notably cod, seabass, sharks or salmon)

**Challenge 1.3: Fishing alters food-web interactions - Box ICES reports**

* WGNSSK: Plaice in 4. A significant release from fishing pressure has led to substantially increased stock size, potentially competing with other benthic foragers that are still under fishing pressure for food resources.
* WGBFAS: Cod Fishery in the Baltic Sea.  The stock size of the Baltic’s small pelagics (herring, sprat and perhaps sticklebacks) are determined by the predation pressure of cod, which is at very low stock size due to (among other causes) fishing.
* WGHAWG: Herring in the North Sea.  Herring is a key link between plankton and predatory fish as well as between offshore and coastal habitats, in and around the North Sea.  High exploitation rates, of both herring and its predators, may release other planktivorous fish  (e.g. sandeel and sprat) with different energy and nutrient flows in the system.

**Challenge 2.1: Inherent ecosystem variability and ecosystem component attributes interact with fishing impacts to affect fishing opportunities - Box EU Partners Input**

* Industrial Fisheries in the North Sea for sandeel and sprat
* Climate change and species interactions: In particular the sandeel fishery is suffering from what appears to be a climatic influence on stock productivity
* Pelagic fisheries for sprat and herring in the Baltic
* Climate change and species interactions: Sprat and herring are affected by predation from cod. At the meantime, Sprat and herring recruitment and growth are affected by climatic variables
* Purse seine (anchovy and others) fishery in the Gulf of Cadiz
* Increased predation on eggs: Southern mackerel (*S. colias*) is expanding due to warming, predation on sardine and anchovy eggs has been put forward
* Increased predation: The recovery of hake, bluefin tuna, dolphins, and orca whale populations have been put forward as a cause of small pelagics (sardine) decrease
* Change in productivity: The management strategy evaluation of sardine in 8c and 9a (special request by Spain and Portugal) asked ICES to assess if the productivity regime of sardine recruitment had changed. New reference points are being discussed
* Demersal trawl fishery for Northern Prawn (3a and 4)
* Top-predators: Natural mortality of prawns is presently low due to weak stocks of demersal predatory fish. This may change following a recovery of these fish stocks.
* Fisheries with passive gears in 3a (creels, traps gillnets)
* Top-predators: The recovery or recent increase of marine mammals and seabirds that act as top predators may increase natural mortality of harvested species leaving less of the biomass for fishing
* German large pelagic freezers
* Adapting fisheries management to climate change: North Sea is projected to warm by about 2°C during the 21 st century under IPPC scenario RCP8.5 and about 1°C under IPPC scenario RCP4.5, with comparable increases at the surface and bottom levels; model projections of European pelagic fisheries show a contrasting picture where some stocks (and the fleet catching them), benefit in the scenarios mid-century while others, such as the North Sea autumn spawning herring, decrease due to continuous reduced recruitment
* Mixed plaice and sole fishery, in Central and southern North Sea
* Climate change and other adverse impacts affect the distribution of demersal species: distribution shift in plaice can be attributed to climate change rather than to ﬁshing, but both play a role in the distribution shift of sole. Climate change impacts eutrophication, prey availability, and habitat modiﬁcation are additional factors for distribution. Information from surveys suggests that in recent years the nursery area of plaice is shifting away from coastal areas and towards offshore areas. Older ages also show a northward expansion in distribution.
* The Dutch Fleet
* Climate change affects the target species i) by affecting the growth and size of individual fish (physiological response) and the extent of cannabilism as larvae, and ii) by affecting population growth, mortality and recruitment, iii) by a changing behavioural and/or phenological responses, such as moving to warmer/colder/deeper areas potentially leading to shifts in the distribution of species (only for juv. & adults, since eggs and larvae depend on currents), and changes in the timing and extent of spawning or feeding migrations. These factors may affect the catch area of the fishing fleet, iv) by affecting other parts of the ecosystem, e.g. plankton, predators, which may indirectly affect the biomass of target species (e.g. earlier plankton spring bloom -> mismatch with fish larvae if spawning of fish does not happen earlier too). Besides, there are risks for ocean acidification, changes in primary production (which may cascade up to higher trophic levels), increased stratification (due to higher temperatures in summer), and increased frequency and length of marine heatwaves (especially in shallow waters that warm up easily)
* Ecosystem change: Changes in community composition, structure, and functioning, may be caused by changes in the environment and/or fishing with increases or decreases in the abundance of species, or the arrival of new species or the disappearance of species.
* Trophic cascade: sole, plaice and other target species in two ways: i) bottom-up: many benthivorous species are planktivorous as larvae, so changes in the plankton community (e.g. due to climatic variation or climate change) may affect the timing of food availability and quality. Juveniles and adults are mostly benthivorous, so food availability and quantity of benthos affect the juvenile and adult part of the stocks; ii) top-down: predators of the target species strongly determine natural mortality, so any changes in the biomass of predators due to environmental change and/or fisheries on predators will affect the target species of the beam trawl fishery. This could be the release of predation on at different life stages (eggs, larvae, juveniles, adults)
* Habitat alteration: increased benthic production in the North Sea during the 1980s and 1990s resulting from the reduction of large demersal fishes due to fishing, with the largest plaice stock ever observed since monitoring began. Climate change with southern, warm-loving Lusitanian fish species has become more abundant in the North Sea (e.g. grey gurnard and Mediterranean scaldfish (*Arnoglossus laterna*), whereas cold-loving, boreal species have decreased (e.g. cod, Atlantic wolffish). New or increasingly abundant species may predate on or compete with resident species with a similar ecological function. The increase in abundance of 'new' species may provide new fishing opportunities, especially when fishing opportunities for other species diminish.
* Portuguese Demersal bottom otter trawl fish fishery, or Gill and trammel nets for demersal fish
* Shreds of evidence of environmental driven fluctuations in the abundance of some of the target species either by pelagic recruitment/juvenile phase or bottom-up effects are driven by species interactions (e.g.predator-prey) with mixed layers habitats. Ocean warming has affected the composition of fisheries landing
* Portuguese Crustacean bottom otter trawl fishery
* Shreds of evidence of environmental driven fluctuations: The temporal pattern of rose shrimp shows high fluctuations in abundance, with periods of several years of very high abundance and some years of low abundance. Catches of rose shrimp have very high fluctuations dependent on the recruitments. The factors that affect the recruitment level are unknown. This species is always the main target species, either because it is caught in shallower areas than the other target Norway lobster and high market value.
* Portuguese Demersal longline fishery in the Azores
* Shreds of evidence of environmental driven fluctuations in the abundance and composition of target and landed species. Ocean warming has affected the composition of fisheries landing
* Portuguese Purse seiners small pelagic fishery
* Recruitment of small pelagic fishes is strongly dependent on good environmental factors. Changes in environmental conditions such as temperature might affect the level of recruitment and consequently of the state of the stock causing the decline of fish populations targeted by the fishery. Alterations on the size of populations of one species might then have an impact on the whole food chain and dynamics between species targeted by the fishery (e.g. decrease in sardine and increase in mackerel and or anchovy)

**Challenge 2.1: Inherent ecosystem variability and ecosystem component attributes interact with fishing impacts to affect fishing opportunities - Box ICES WGs reports**

* NIPAG: Pandalus in the Skagerrak and Norwegian Deep. Seasonality effects on catchability. Landings per unit effort differ throughout the year, but the mechanism behind this is unknown.
* WGEEL: European eel across European range. The north-south variation in temperature and food availability affects the growth rate and age at the maturation of yellow eel. This results in different demographic rates across a same stock.
* WGWIDE: Norwegian spring-spawning herring. Pelagic water conditions drive stock distribution shifts. Changes in zooplankton productivity and interspecific competition with mackerel have forced NSS herring westward in recent years.
* WGNSSK: Mixed demersal trawl fishery of the North Sea. The complexity of interactions between species, many of which are exploited, makes modelling changes over the whole system a challenge. Regarding Multi-species models: "There are many direct and indirect interactions between species, making it difficult to reach a single and robust best solution. Optimization scenarios carried out so far show that the result (target F) depends very much on the objectives (objective function) and SSB constraints used."
* WKBALTIC: Cod fisheries in the Baltic Sea. Low benthic productivity could be causing population bottleneck at early life-history stages—potential competition between adults of other species and juveniles of cod.
* WKBALTIC: All fishing in the Baltic Sea. Regime shifts can cause changes in fish assemblage structure. Substantial changes in assemblage structure, such as large increases in stickle back abundance. These are both potentially unwanted and a new targeted catch. Indirect effects in food-web and as un-modelled parameters affecting fishery models for other species.
* WGDEEP: Blackspot Seabream in 6, 7, & 8. Following historically high fishing pressure there has been a shift in the stratification and temperature regime of waters in the Celtic seas and Bay of Biscay, which are unfavorable to the blackspot seabream and may prevent stock recovery.
* WGHAWG: Herring in 20-24. Larval survival and year-class strength are linked to oceanographic dispersal and pelagic environmental conditions, not least of all planktonic food availability at the time of first feeding.
* WGCSE: Seabass in 4b & c, and 7d-h. Warming ocean conditions allow the northward expansion of seabass’ range into the North Sea and North-East Atlantic, enhancing juvenile survival in coastal nursery habitats.

**Challenge 2.2: Anthropogenic environmental changes interact with fishing opportunities individually or cumulatively - Box Partners Input**

* The multi-fleet fishery for herring
* The Western Baltic Herring stock is declining rapidly, and current predictions indicate that it may decline even further even without a fishery. Recruitment has been declining for five consecutive years. The reason remains unknown (but could be related to changes in the environment). North Sea herring, on the other hand, has rebuilt and is now well above biomass limit reference points, although poor recruitment in recent years has sparked some concern.
* Demersal trawling for *Pandalus Borealis* in Skaggerak and Norwegian Deep (3.a and 4.a East)
* The distribution of the population in the stock area has changed, and biomass and recruitment have generally declined in recent time. These changes are potentially linked to climate change-related temperature increases, as Skagerrak is on the southern border of the overall distribution area of this northern hemisphere cold-water species.
* Mixed demersal trawling fisheries for cod & flatfish in the West Baltic
* Eutrophication: create concerns on coastal fishing opportunities (e.g. by changing vital rates). Besides, a critically reduced cod stock might not be able to maintain its central position in the food-web. Novel food-webs might emerge, with so far unknown specifications. Eutrophication is an issue for cod in the eastern Baltic.
* Hypoxia: Eutrophication affects oxygen conditions, which has adverse effects on cod physiology and also on benthic prey availability, and thereby affects cod growth and condition and consequently fishing opportunities
* Climate affects recruitment of commercial fish and thereby stock size, and may also affect the distribution of fish, e.g. coastal vs offshore distribution Possible change in survey catchability due to increased areas with hypoxia
* Climate: Climate affects the hydrographic conditions for cod reproduction. Climate impacts on oxygen conditions may also impact the availability of benthic prey
* Grey seals affect cod through predation and parasite infestation, with adverse effects on its growth, condition and natural mortality, and thereby affect fishing opportunities
* Sprat and herring are more northerly distributed, with limited overlap with cod in the southern Baltic Sea. This may imply a food limitation for cod in the southern Baltic Sea. Further close to 50% of the sprat catches are taken in ICES SD 25 and SD 26 cod main distribution area
* Mixed demersal trawling fisheries for cod & flatfish in the Central Baltic
* Eutrophication and increased hypoxia areas are negatively influencing recruitment of demersal fish species as well as their feeding conditions - hypoxic areas decrease benthic prey abundance
Pelagic trawling fisheries in the Central Baltic Sea
* Highly variable pelagic fish recruitment success due to climate-driven changes
* Small scale fishery in Latvian coastal waters
* Invasion of round goby in coastal seas
* Increase of abundance of seals: The number of grey seals in Latvian coastal waters increased significantly; as a result, damage of fishing gears and damaged landings are registered in coastal fishery waters
* Striped Venus clam (*Chamelea gallina*) fishery in the Gulf of Cadiz
* Land-based effects (rice production) on recruitment: Freshwater discharges regulation for rice agriculture purposes in the Guadalquivir River (salinity/turbidity) may have an impact (via recruitment/settlement) on this fishery
* Acidification: Possible effects on larvae and seed hypothesised and currently being studied
* Mixed trawl fisheries for flatfish or Nephrops in Central North Sea
* Reduced biomass at length for commercial fish species like Dover sole, European plaice
* Pathogen: Pathogens (bacteria, viruses, parasites etc.) occurring in the natural environment and contributing to natural mortality
* Climate change: unpredictable future and ongoing changes in geographical fish distribution, consequent changes in catch composition between species, changes in reproduction of commercial species. e.g. regime shift in the North Sea (the eighties), e.g. lower cod biomass in the southern North Sea, higher plaice biomass
* Mixed demersal trawling fisheries for whitefish and Nephrops in the Celtic Sea
* Climate change: Increasing temperatures due to climate change, and modulations in that due to AMO etc. impacts
* Mixed demersal trawling fisheries for cod & flatfish in the eastern Baltic (bottom trawl, spawning time)
* Considerable increase of parasitic infection in 2012-2019 (liver worm - Contracaecum osculatum) from a few % to 90%. Infection dispersed to the entire area of the southern Baltic. It leads to significantly declining cod body condition and probably increase in natural mortality.
* Hypoxia: Reduced area of cod bottom distribution and also cod prey availability. Shrinkage of cod spawning areas. Changes in cod metabolism. Prespawning migrations of eastern Baltic cod to western Baltic spawning area of Arkona Basin
* Spatial overlap: predation of clupeids on cod eggs, migration of clupeids to north-eastern Baltic in autumn (cod food reduction)
* Salinity: Low frequency of saline water inflows from the North Sea leads to salinity changes and (together with eutrophication) results in hypoxic conditions at the bottom, which may affect/limit flounder spawning. The extension of habitats suitable for reproduction and thus supporting the stock vary greatly, affecting both stock abundance and species distribution
* flatfish fishery along the Polish coastline
* Round goby increases competition for space and food resources with native species of commercial value as flatfish
* Salmon fisheries of mixed stocks (both in good and poor conditions)
* poor conditions of river environment due to mechanical barriers: dams, hydroelectric power plants; eutrophication; inadequate bottom structure; disorders and turbulence; effects of climate change and global warming (lower river levels during fish migration; not appropriate water temperature.
* Demersal trawl fishery for Nephrops and fish (3a and 4)
* Climate change: Changes in temperature leads to changes in the distribution (latitude and depth) of harvested species. Fishing practices and quotas may not be adjusted for that. With increasing temperature and freshening, stratification and oxygen consumption will increase, possibly leading to hypoxia affecting the growth, survival and distribution of harvested species
* Swedish Pelagic fisheries with active gears
* Climate change: Changes in temperature leads to changes in the distribution (latitude and depth) of harvested species. The dominant zooplanktivores fish species may be impacted by climate change-driven shifts in the community structure of primary producers and zooplankton
* Fisheries with passive gears in 3a (creels, traps gillnets)
* Eutrophication: Eutrophication will act in several ways to change the niches of demersal fish species, but most notably by reducing possible fishing grounds through oxygen deficiency. Eutrophication may increase algal blooms and alter habitat complexity through a shift from perennial macro vegetation to phytoplankton and filamentous algae
* Beam trawl, mesh 33-70mm, mussel fishery, Eastern North Sea (German coast)
* management of invasive species (for Federal State of Lower Saxony) for the risk of introducing non-native species
* The Dutch Fleet
* Habitat alteration: Construction of offshore wind farms, oil and gas platforms, seismic operations, and sand extraction. Artificial structures result in a direct loss of habitat but might be beneficial for fish stocks when they result in closed areas for fishing. Also may provide few more fishing opportunities for passive fishing gears (e.g. for edible/brown crab) and the cultivation of mussels and seaweeds.
* Environment: temperature, salinity, water inflow and currents, chlorophyll-a and climatic indices, may influence fish growth, mortality and recruitment, and spatial distribution including feeding grounds, spawning grounds, nursery areas. Correlations are weak, however.
* Mixed demersal trawling fisheries operating in ICES divisions VIII and VII
* Climate change: changes in the spatial distribution (northward shift of the distribution limits) of the demersal fish species due to climate change. Changes in the distribution (northward shift of the distribution limits) of other target species such as Atlantic Mackerel, with change the timing of the spawning migration to the southern area of the Northeast Atlantic mackerel population
* Spanish purse seiner targeting small pelagic fishes
* Climate change, warming is causing species shifts to Northern area
* Changes in the predation mortality of small pelagic species due to warming: Given the earlier spawning of Atlantic mackerel in the Bay of Biscay, an increase in their potential to predate upon sardine (mainly) and anchovy (probably) predation is hypothesized
* Changes in the condition of some pelagic species. A decrease in weight and size of some pelagic species has been found in the last decade. This might be related to poorer environmental conditions (as it seems to be the case for sardine and mackerel) or also due to the high recruitment events (as for anchovy), in which even the individuals with worse conditions, also survived.
* Spanish gillnets and Trammel nets or longline operating in the BoB & Iberian Waters ecoregion
* Changes in the distribution (northward shift of the distribution limits) of the demersal fish species due to climate change
* French fleets in the Bay of Biscay
* Eutrophication/Turbidity: The latest French Marine Strategy documents (2019) indicate a high risk of turbidity in some coastal areas of the Bay of Biscay (Loire, Perthuis Charentais, Gironde, Arcachon).
* French vessels targeting hake in the Bay of Biscay and in North Western Waters
* Climate change changing spatial distribution of fish stocks: The main target of this fleet, hake, is showing a shift in its geographical distribution towards northern areas, but also in the North Sea
* French fleets in the English Channel
* Eutrophication/Turbidity: The coastal areas of the English Channel are listed as essential areas for several species targeted by the coastal trawlers fleets (spawning areas, nurseries), which are sensitive to eutrophication and sediment input. The latest French Marine Strategy documents (2019) indicate a high risk of turbidity in most coastal areas of the English Channel
* French Demersal trawlers in the North Sea and North Western Waters (Saithe)
* Climate change changing spatial fish distribution: One of the main target of this fleet, saithe, is showing a shift in its geographical distribution

**Challenge 2.2: Anthropogenic environmental changes interact with fishing opportunities individually or cumulatively - Box ICES WGs reports input**

* WGBFAS: Non-indigenous species. Introduction rates of non-indigenous species have more than doubled in the 21st century, compared to the period before (3.2 vs 1.4 species per year). These impact fisheries directly (e.g., declines in native, target species abundance/biomass and fouling of fishing gears) and indirectly (e.g., changes in the physio-chemical habitat of sediments and water and changes in food-webs).
* WGBFAS: Cod in the Kattegat. Ontogenetic migration of Skagerrak cod means that smaller individuals originating from the Skagerrak/North Sea may migrate away from the Kattegat, essentially increasing unallocated removals not accounted for in natural mortality or estimates of fishing pressure.
* WGBFAS: Cod in the Kattegat and Baltic Sea. Potential increase in natural mortality derived from the predation from recovering seal populations. Rates of seal predation on cod are unknown.
* WKDEM: Cod west of Scotland. The degree of overlap, and therefore true predation pressure, between seals and cod is unknown, introducing a large error in the estimated natural mortality used in assessment models.
* WGBIE: Hake in 8c & 9a, and Seabass in 8a & b. Unknown drivers of recruitment introduce more uncertainty into forecasting for advice on fisheries opportunities.
* WGDEEP: Blackspot Seabream in 9. Food web challenges (increased predation from recovering bluefin tuna stocks) interact with long-term environmental changes (migration patterns and overall distribution of blackspot seabream) to increase the complexity involved in trying to predict future states of the fishery.
* WGDEEP: Blackspot Seabream in 10. Unknown drivers of interannual catch variability introduce more uncertainty into forecasting for advice on fisheries opportunities.
* WGDEEP: Black scabbardfish across all western waters. The black scabbard fish is thought to complete it is life cycle over a large latitudinal scale with spawning and juvenile habitats around Madeira and Canary Islands, recruits in Northern waters (Iceland and West of Scotland) and the main fishery of adults with different levels of maturity in between. This makes one stock exposed to multiple fisheries.
* WGHANSA: Anchovy in 8 and 9a: The anchovy recruits into the fishery at age 0-1, and these ages comprise the bulk of the landings. Therefore, there is little time for surveys to assess stock biomass before the fishery takes effect.
* WGHAWG: Herring across Europe. Many correlations between environmental conditions and stock productivity have been identified, but there is a lack of evidence for mechanistic, causative relationships that allow a real understanding of environmental drivers. One specific example is the decrease in mean weight-at-age for many herring stocks.

**Challenge 3.1: Social and governance constraints on fishing opportunities - Box Partners Input**

* Demersal trawling for *Pandalus Borealis* in Skagerrak and Norwegian Deep (3.a and 4.a East)
* The stock dynamics and fishery is influenced by over-capacity in the fleets of the two neighbouring countries (Sweden and Norway), which means that high-grading and discarding of shrimp have been an issue in these two countries. These issues have resulted in red light for Skagerrak shrimp from WWF in their seafood consumer guide, which has influenced the market demand and prices.
* Mixed demersal trawling fisheries for cod & flatfish in the West Baltic
* Technical interaction: competition from the inshore national fleet could become an issue if the fleet is forced to occupy a reduced spatial geographic footprint than was previously the case, for example, by spatial closures.
* Pelagic trawling fisheries in the Central Baltic Sea
* Mixed fisheries. The Baltic herring fisheries often land also sprat and vice versa. This can lead to species misreporting
* Small scale fishery in Latvian coastal waters
* For the moment round goby fishery is a second most important small-scale fishery in Latvian zone. However, market possibilities are limited and in case of lost this market, round goby fishery could change from the opportunity for fishermen to threat to coastal ecosystem
* Purse seine (anchovy and others) fishery in the Gulf of Cadiz
* Fishing rights: Conflict when the SFPA EU-Morocco expires, as those vessels fishing in Morocco must come back to the Gulf of Cadiz
* More TACs: TACs are only given for Gulf of Cadiz anchovy, which is the most valuable small pelagic in the GoC. Fishers are demanding management of other species: sardine, horse mackerel, southern mackerel, through flexible plans (e.g., quota exchange).
* Striped Venus clam (*Chamelea gallina*) fishery in the Gulf of Cadiz
* Hydraulic dredge can reach shallower wedge clam banks in high tide, creating continuous conflict with artisanal fishers
* Mixed beam trawl fisheries for flatfish in the North Sea
* Competition for space with windmill parks, aquaculture activities and nature parks may cause loss of fishing grounds and an increased density of fishing vessels, which may compromise profitability (e.g., competition between Belgian beam and Dutch pulse trawl.
* Brexit: Uncertainty on the future of fishing grounds in UK waters.
* LO: LO legislation came into force, but compliance is low (due to limited enforcement? and limited communication with fishers themselves?). Discards not reported correctly in e-logbooks => effect on data collection and processing by scientific institutes.
* Crew: A lack of skilled crew members. Crew members may have foreign origin increasing communication difficulties and safety. Crew requires awareness on good practices (e.g. application of the LO).
* Mixed demersal trawling fisheries for whitefish and Nephrops in the Celtic Sea
* Landing Obligation still represents a challenge though anecdotal information suggests little compliance. In addition, the CFP relative stability is considered as highly restrictive by Irish fleet.
* Economic aspects: Many fishing vessels may be fishing at a point where the economic return is minimal, possibly lower than rent return
* Mixed demersal trawling fisheries for cod & flatfish in the eastern Baltic (bottom trawl, spawning time)
* Fisheries management measures often include spatio-temporal closures during the spawning period of the fish with an overarching aim of improving the stock status. There is a need to assess how those spawning closures influence the stock condition—conflict of interests with other fisheries.
* Other fisheries management: Emergency measures introduced in 2019 limited commercial fishing for Baltic cod to small quotas available for bycatch only. This may negatively affect flatfish fisheries normally conducted by the same fleets. Need for monitoring and adaptive cod quota management in order to keep flatfish fisheries unaffected
* Fisheries with passive gears in 3a (creels, traps gillnets)
* Demersal species in Sweden are managed by annual transferable quota shares for vessels with active gears. This system also includes Nephrops creels and vessels >12 m using passive gears. The rest of the small-scale fisheries have a pool quota system. The quota volumes set aside for this passive gear fishery are central for the development of this fishery and a potential conflict area in national quota allocation.
* 0-catch quota: Eastern Baltic cod used to be the main target species for a large fleet of vessels but is now a by-catch species with a very limited quota. Alternative species such as flatfish and freshwater species are less profitable. In addition, a seasonal fishing ban is implemented, which further reduces profitability.
* beam trawl (TBB), North Sea, the shrimp fishery
* Use-conflicts with offshore wind energy (do not only affect shrimp fishery but trawls in general)
* German large pelagic freezers
* Access to British fishing grounds is being negotiated in the context of Brexit
* German Mixed plaice and sole fishery, Central and southern North Sea, or Demersal seine saithe fishery and cod, or Gillnet, Sole fishery, Southern North Sea
* Fisheries management/ regulation in MPAs in the EEZ and territorial seas
* German Cod fishery, Western and central Baltic sea
* Spawning closures for cod are beneficial for recruitment (not necessarily for the reduction of fishing mortality, but to improve spawning conditions, for example by avoiding disruption of spawning aggregations
* NLD Traditional tickler beam trawl fishery targeting sole and plaice, or Pulse trawl fishery targeting sole and plaice’, or Bottom trawl and seines fishery, or Passive fishery, or Pelagic freezer trawler fishery (Lot1 & 2 areas)
* Closed areas: Impact of closed areas (e.g., vulnerable marine ecosystems (VMEs), plaice box, windfarms on (i) different species (communities) that are harvested by the mixed demersal trawl fishery, and (ii) distribution of the fishery in time and space
* Spanish Mixed demersal trawling fisheries operating in ICES divisions VIII and VII
* Choked fleet: Because of having choke species in the system, a decrease in the effort of some fisheries could be choked: once the LO is implemented
* Selectivity: Improvements in selectivity promoted by the implementation of different regulations, including the landing obligation, might cause losses in the productivity of the system
* LO: The implementation of the LO is causing economic loss on some fisheries. The potential effects of this economic loss should be further analyzed.
* MPAs: Fishing reserves, Special Areas of Conservation (SACs) and Special Protection Areas (SPAs) are established (within the Natura2000 network).
* Spanish Gillnets and Trammel nets operating in the BoB & Iberian Waters ecoregion
* Fishing reserves, Special Areas of Conservation (SACs) and Special Protection Areas (SPAs) are established (within the Natura2000 network).
* Spanish Longlines targeting demersal species
* Fishing reserves, Special Areas of Conservation (SACs) and Special Protection Areas (SPAs) are established (within the Natura2000 network).
* Portuguese Demersal bottom otter trawl fish fishery
* Important target/bycatch species for this métier have no assessment/advice and others are cat.3 stocks. Demersal stocks which lack an analytical assessment. Improvement of area-specific species knowledge and advice outside the current ICES "list" of species;
* The effectiveness of LO policy is to be assessed
* The French fleet in the Bay of Biscay
* Maritime Spatial Planning: At this stage, two zones have been designated in the Bay of Biscay for the development of offshore wind farms. More zones are due to be designated in 2020. Currently, in development, these new installations may have some significant impacts on some coastal fleets, notably coastal demersal trawlers in the area between Yeu and Noirmoutier
* The French fleet in the Celtic Sea or the English Channel
* Maritime Spatial Planning: At this stage, four zones have been designated in the English Channel for the development of offshore wind farms. More zones are due to be designated in 2020. Currently, in development, these new installations may have some significant impacts on some coastal fleets, notably coastal demersal trawlers in the Bay of Saint Brieuc
* French Pots and traps targeting large crustaceans in the Celtic Sea
* None of the large crustaceans targeted by these vessels is quota-regulated
* French Netters fleets in the English Channel targeting fish
* High dependence to overfished stocks: Sole is one of the main target stock of netters below 12m in the ICES zone 7d, currently not at MSY.
* Maritime Spatial Planning constraining the fishing areas
* French Pelagic trawl targeting small pelagic species in the North Sea and North Western Waters
* International negotiations have been difficult for several small pelagic species (mackerel, herring notably), hindering the ability of managers to set total quotas in line with the scientific advice, thus lowering the fishing opportunities of this fleet.

**Challenge 3.1: Social and governance constraints on fishing opportunities - Box ICES WGs reports**

* WGBFAS: Plaice in 24-32. The landing obligation for plaice at the edge of its range means that there was a sharp increase in below minimum size landings that were previously discarded.
* WGBFAS: Sole in 20-24. Closed area to protect cod spawning grounds also excludes sole fishery.
* WGEEL: Eel in transitional waters (Europe wide). Multi-use of transitional waters including damning and power generation, restrict migration and increase mortality.
* WGEEL: Eel across Europe. The variation in fishing method, life stage targeted and local regulations on eel fishing mean that exploitation rates are not compatible across the species' range.
* WGEEL: Eel in Northern Europe: Juvenile glass eels are captured at sea in southern waters and are transported and re-released into northern waters to increase local recruitment.
* WGWIDE: North East Atlantic Mackerel. There are international agreements in place to set TAC by a regulatory body. However, all TACs have been set above advice.
* WGNSSK: Mixed demersal trawling fisheries in the North Sea. Due to the low societal and commercial value placed on some species (e.g., flounder and dab), the data on catch-rates and discards is less reliable or not reported.
* WKBALTIC: All Fishing. Inaccuracies in scaling (raising) discards across un-sampled fractions of the fishery.
* WGBIE: Nephrops 8a & b. Technical regulations (minimum landing sizes, effort restrictions, gear selectivity requirements) change the patterns of landings and discards introducing unaccounted variation in assessment models and therefore more uncertainty in advice on fishing opportunities.
* WGBIE: Nephrops 9, 10 & CECAF 34.1. "The five Nephrops FUs (assessed as 3 separate stocks) are managed jointly, with a single TAC set for the whole of Subareas 9, 10 and CECAF 34.1.1. This may lead to unbalanced exploitation of the individual stocks. The northernmost stocks (FUs 26-27) are at extremely low levels, whereas the southern ones (FUs 28-29 and FU 30) are in better condition."
* WGHANSA: Sardine 8c & 9a. In the absence of regular surveys (e.g., due to SARS CoV2 pandemic) assessments cannot be updated nor new advice developed.
* WGHAWG: Herring all areas. Coastal spawning and juvenile habitats mean herring are sensitive to anthropogenic impacts other than fishing. The most serious of which comes from increased competition for space, particularly with sand and gravel extraction operations and increasingly wind farms.
* WGCSE: Cod in 6a. Misreported landings (attributed to different areas than the fished area) accounted for 60% of landings in 2018.
* WGSCE: Cod in 7a. Severely depleted stocks and fisheries closures result in fewer data and hence less visibility of stock development and development of other now-excluded species.
* WGSCE: Nephrops FU16. Seasonal closures are implemented but not evaluated as management tools for unwanted bycatch. This leads to potential misuse as fishers prefer temporal closures to catch limits.
* WGSCE: Seabass 4b, c, & 7d-h. Quote: "first-sale value of the high-volume and lower quality catches of seabass caught by pelagic trawlers targeting offshore spawning fish during December to March has been up to three times lower per kg than for smaller volume sales of higher-quality fish for métiers fishing inshore". Citation Drogou et al. 2011.
* WGSCE: Whiting 6a, b, 7b, c, & e-k. Whiting as a low-value species is often caught together with high-value species (such as Nephrops). Historically this resulted in high discard rates, but as a TAC species, under the landing obligation, it will likely limit the catches of the high-value target species.

**Challenge 3.2: Conflicting, inconsistent or ill-informed policy goals across industries and stakeholders - Box Partners Input**

* Industrial fisheries in the North Sea for sandeel and sprat
* A major fraction of the Danish sandeel landings takes place in UK waters (just across the EEZ boundary transecting the Dogger bank). Another issue has to do with the border between the Norwegian EEZ and EU waters, which is not fully compatible with spatial biological stock divisions and structures.
* Pelagic fishery for Atlantic mackerel in the North Sea
* Mackerel distribution and biomass have changed considerably in recent time, creating some uncertainty about the proportion of the stock that resides in the North Sea. This has raised the question of how the quota is best allocated among areas and nations given the distribution and/or population structure has changed.
* A multi-fleet fishery for herring
* The fishery targeting the western Baltic Spring Spawning herring consists of multiple fleets fishing in areas from the Baltic to the North Sea. Since the quotas can be moved between fleets and areas, this poses a major problem when forecasting catch opportunities. No major challenges were identified for North Sea herring, although unnoted bycatch of Western Baltic Spring Spawning herring has become a potential challenge as the Western Baltic Spring spawning herring stock has declined to below biomass limit reference points.
* Mixed demersal trawling fisheries for cod & flatfish in the West Baltic
* Mixed fisheries for eastern and western Baltic cod within the management area of the western Baltic cod.
* Recreational catches are accounting for close to 1/3 of the total catch. Presently that is regulated by bag limits.
* Mixed demersal trawling fisheries for cod & flatfish in the Central Baltic
* Due to the critical status of Eastern Baltic cod stock, a specialized cod fishery is forbidden
* Purse seine (anchovy and others) fishery in the Gulf of Cadiz
* Land-based effects: A trade-off between the regulation of the freshwater discharge for rice agriculture purposes in the Guadalquivir estuary (a nursery area for anchovy) and the impact this may have on anchovy population
* Mixed demersal trawling fisheries for whitefish and Nephrops in the Celtic Sea
* Social aspect: Identification of "fishing ports" is poorly developed in Ireland. Fishing ports are only registration ports, and these are few and not really fishing ports
* Demersal trawl fishery for Nephrops and fish (3a and 4)
* Spatial restrictions imposed for bottom trawling due to adherence to new or revised N2K-demands. In addition, national revision of trawling allowances in sensitive habitats on national waters is underway
* LO: Landing obligation puts focus on choke issues particularly in the mixed Nephrops/fish trawl fishery due to quota imbalances between Nephrops and demersal fish
* Swedish Pelagic fisheries with active gears
* Pelagic species in Sweden are under ITQs whereas demersal species are managed by annual transferable quotas. Pelagic vessels have no track-record and are thus not allocated quotas for demersal species, which are sometimes caught as bycatch in their directed fisheries
* German Cod fishery, Western and central Baltic sea
* Competition with recreational fisheries; 161 000 recreational fishers, from all German shores and from boats (charter and private boats) mostly within 5 nautical miles (NM) of the coast. represents 27% of the total removals
* longlines, eel fishery, Western Baltic Sea
* There is no internationally coordinated eel management plan for the whole stock area, which extends beyond the EU
* NLD Traditional tickler beam trawl fishery targeting sole and plaice, or Pulse trawl fishery targeting sole and plaice’, or Bottom trawl and seines fishery, or Passive fishery, or Pelagic freezer trawler fishery (Lot1 & 2 areas)
* Brexit has created uncertainty over access to fishing grounds and national allocations of EU Total Allowable Catches (TACs) by fish species. Dutch fisheries are highly dependent on the UK EEZ, where bottom trawlers (including the traditional beam trawl fishery) partly fish in the UK EEZ. Based on revenues, the bottom trawler fleet depends up to 30% on UK waters. Depending on the outcome of the Brexit, it may possibly lead to a change in fishing areas, fleet composition and/or catches
* LO: The EU obligation to land all catches of undersized fish quota species was phased in these fisheries from 2016-2019. As this entails a mixed fishery, where discarding is inevitable, a fully implemented landing obligation would be challenging. The fisheries received an exemption for the landing obligation for a number of quota species. Exemptions are documented in discard plans that have been evaluated and approved by the STECF. The plans have a maximum duration of 3 years and eventually, the provisions of the landing obligation will eventually become incorporated into Multi Annual Plans.
* Pulse trawl: use of electricity in catching fish is illegal under EU law. In 2006, EU derogation to use the pulse trawls for a maximum of 5% of the vessels resulted in 22 licences. In 2011, an additional 20 licences were granted. In 2014, another 42 temporary licences were granted -> 84 licences to catch sole using pulse trawl. The increase in the number of licenses, negotiated by the Dutch government with the EC was there to accommodate the interest of the fleet. There was a lot of campaigning against pulse fishing which in the end led to the EU decision to maintain the ban on pulse trawling in the Technical Management Regulations (CEC, 2019). This resulted in part of the Dutch pulse fleet switching back to the traditional beam trawl fishery
* Shifting spatial distribution: for pelagics, Species may shift their distribution in response to changes in the environment. Some species already have done so in response to climate change. When stocks cross country borders and enter new EEZs, this may cause conflicts between countries regarding the management of such stocks. Unresolved conflicts could lead to overexploitation. This challenge particularly applies to highly mobile pelagic species, and conflicts already have already occurred or are ongoing for Northeast Atlantic mackerel and Norwegian spring-spawning herring.
* Portuguese Longlines for black scabbardfish
* fishery management unit: The stock structure in the whole Northeast Atlantic is still uncertain. Nevertheless, all the available information supports the assumption of a single stock-based. However, the advice is separated by area;
* The Parasite (Anisakis) infestation can be a risk for human consumption
* Portuguese Gill and trammel nets for demersal fish
* Stock knowledge and improvement of fisheries management applied to other data-poor species outside DCF
* Technical interactions among fishing net gears, and target species biological interactions are not known
* Purse seiners for SPF fishery (PS\_SPF\_16\_0\_0)
* Connectivity and dynamic patterns of the Iberian sardine stock suggest a meta-population with three weakly connected populations and density-dependent source-sink movement within the northern Spanish and Portuguese waters population. While the weak connectivity does not invalidate the management boundary between the Bay of Biscay and the Iberian Peninsula, the Gulf of Cadiz may be treated as a separate stock.

**Challenge 3.2: Conflicting, inconsistent or ill-informed policy goals across industries and stakeholders - Box ICES WGs reports**

* WGBIE: Seabass in 8a & b. Recreational fisheries are an important part of the total removals, but these are not accurately quantified.
* WGBFAS: Cod in the Western Baltic Sea. Recreational catches are substantial but not as well monitored or reported as the commercial catches.  This increases uncertainty in assessment and advice as well as increasing the risk of overexploitation.  Recreational catches are estimated from what data is available, but further improvement for part-time fishers and small vessels needs to be improved.
* WGBFAS: Cod, herring and sprat in the Baltic Sea. The use of single-species assessment is less efficient than multispecies plans utilising the Nash Equilibrium.
* WGBFAS: Cod from Eastern and Western Baltic Stocks. There exist overlaps in stock ranges so that the management units do not entirely align with a single stock. This means that catches of one stock may be supplemented/masked in any given management unit.
* WGEEL: The range of the eel extends outside of EU borders, and thus EU regulation only applies to EU fleet, thus imposing potentially more onerous regulation on EU vessels than neighbouring states.
* WGWIDE: Western horse mackerel. The range of this stock extends outside of EU borders, and thus EU regulation only applies to the EU fleet, thus imposing potentially more onerous regulation on EU vessels than other states.
* WGMIXFISH: Mixed demersal trawl fisheries of the North Sea. Errors and uncertainties from single-species stock assessment models are propagated up through models of mixed fishery interactions.
* WGMIXFISH & WKNSSK: Mixed demersal trawl fisheries of the North and Celtic Seas. Within the management area, different habitats/areas are assessed independently but managed (TAC) together. This results in over or under exploitation for an individual species (e.g. Norwegian lobster) risking extirpation in one area and suboptimal exploitation in another.
* WGMIXFISH: Mixed demersal trawl fisheries of the North and Celtic Seas. Due to the data volume and complexity required to run multispecies assessments, active participation of people familiar with each nation's data collection programme is necessary to ensure accuracy.
* WGNSSK: Plaice in 4. A significant reduction in fishing pressure for plaice in the North Sea over the last decade has seen a substantial increase in numbers/biomass. This increase is likely to place increased pressure on benthic producers, the main prey of plaice. There are already indications that plaice condition is being impacted by density dependence.
* WGNSSK: Mixed demersal trawl fisheries in the North Sea. Management focus on the most vulnerable species in a mixed fishery reduces fishing opportunity and yield for other species.
* WGNSSK: Witch and lemon sole in 4. Assessors were requested to combine two species of flatfish in one assessment. The different biology and ecology of these species mean that a joint assessment likely masks potential issues with one or both species.
* WKBALTIC: Small pelagics in the Baltic Sea. Perceived inaccuracies in stock assessments and resulting TACs reduce fishers' trust in the science. Fishers then misreport one species as another (sprat as herring) to allow them to land more fish. This, in turn, misinforms the assessment making the advised TAC less appropriate and further reducing trust in the science.
* WKBALTIC: Western Baltic spring-spawning herring. Stock assessments based on catches in one area, where multiple stocks are fished together. Not a reliable reflection of the stock as multiple stocks can't be disentangled from the data used to inform the assessment.
* WKBALTIC: Western Baltic mixed fishery. Management focus on the most vulnerable species in a mixed fishery (Cod) reduces fishing opportunity and yield for other species (plaice, sole, herring, sprat).
* WKBALTIC: All Fishing. Productivity differs in space and time, often with larger variation at smaller spatial resolution than surveys and stock definitions.
* WKBALTIC: All Fishing. Rapid changes in advised quota are detrimental to fisher/industry financial/strategic planning.
* WKBALTIC: All Fishing. Recreational catches are not as well documented as the commercial catches.
* WKDEM: Cod-West of Scotland. Three distinct stocks have data collected and are assessed as one.
* WKDEM - WGBIE: Whiting in 3.a; Megrim in 7b-k, 8a, b, & d; Sole 8c & 9a. The exploitation of new species, a species not previously exploited in a particular area (e.g. whiting3a), or a species recently separated out from a species complex (e.g. sole 8c, 9a) means that there may not be sources of catch or survey data available to undertake a data-informed assessment.
* WGBIE. Anglerfish 7, 8a-d & 9a. While the two species of anglerfish are assessed independently, they are managed together.
* WGBIE: Megrim in 7b-k, 8a-d & 9a. Not identified to the species level in landings. (some areas are as of 2019).
* WGCSE: Anglerfish in 3a, 4 & 6. The management of these species lacks a specific plan or set of harvest control rules. After evaluating various stakeholder initiated alternative management options, there still lacks a clear plan. Further work needs to be done to reach a viable and agreeable management strategy.

# References used by partners

**AZTI**

Andonegi, E., Corrales, X., Prellezo, R. Ecosystem response to changes in fishing activity: An analysis of the consequences of the landing obligation in the Bay of Biscay. In preparation.

Arcos, J.M., Bécares, J., Villero, D., Brotons, L., Rodríguez, B., Ruiz, A., 2012. Assessing the location and stability of foraging hotspots for pelagic seabirds: An approach to identify marine Important Bird Areas (IBAs) in Spain. Biol. Conserv. 156, 30–42. <https://doi.org/10.1016/j.biocon.2011.12.011>

Arroyo N-L, Preciado I, López-López L, Muñoz I, Punzón A (2017) Trophic mechanisms underlying bentho-demersal community recovery in the north-east Atlantic. Journal of Applied Ecology 54 (6), 1957-1967. <https://doi.org/10.1111/1365-2664.12879>

Bentorcha, A., Gascuel, D., Guenette, S., 2017. Using trophic models to assess the impact of fishing in the Bay of Biscay and the Celtic Sea. Aquat. Living Resour. 30. <https://doi.org/10.1051/alr/2017006>

Bicknell, A.W.J., Oro, D., Camphuysen, K.C.J., Votier, S.C., 2013. Potential consequences of discard reform for seabird communities. J. Appl. Ecol. 50, 649–658. <https://doi.org/10.1111/1365-2664.12072>

Boué, A., Louzao, M., Arcos, J.M., Delord, K., Weimerskirch, H., Cortés, V., Barros, N., Guilford, T., Muñoz Arroyo, G., Oro, D., Andrade, J., Garcia, D., Dalloyau, S., González-Solís, J., Wynn, R., Micol, T., 2013. Recent and current research on Balearic shearwater on colonies and in Atlantic and Mediterranean areas, in: First Meeting of the Population and Conservation Status Working Group. pp. 1–19.

Bruge, A., P. Alvarez, A. Fontán, U. Cotano, and G. Chust. 2016. Thermal Niche Tracking and Future Distribution of Atlantic Mackerel Spawning in Response to Ocean Warming. Frontiers in Marine Science 3.

Bruge, A., P. Alvarez, A. Fontán, U. Cotano, and G. Chust. 2016. Thermal Niche Tracking and Future Distribution of Atlantic Mackerel Spawning in Response to Ocean Warming. Frontiers in Marine Science 3.

Cama, A., Arbona, P., Bernal, M., Carquijero, E., Carquijero, L., Cortés, V., Fernández-Gil, B., García, D., Lorenzi, M.R., Louzao, M., Luque, N., Murcia, J.L., Pauly, M., Pérez, P., Petrelli, C., Rincón, A., Sarzo, B., Tejerina, R., Uranga, U. (2014) Encuestas sobre pesca y aves marinas en España Peninsular y Baleares. Report for the LIFE-INDEMARES project.

Depestele, J., Rochet, M.-J., Dorémus, G., Laffargue, P., Stienen, E.W.M., 2016. Favorites and leftovers on the menu of scavenging seabirds: modelling spatiotemporal variation in discard consumption. Can. J. Fish. Aquat. Sci. 73, 1446–1459. <https://doi.org/10.1139/cjfas-2015-0326>

Erauskin-Extramiana, M., P. Alvarez, H. Arrizabalaga, L. Ibaibarriaga, A. Uriarte, U. Cotano, M. Santos, L. Ferrer, A. Cabré, and X. Irigoien. 2019. Historical trends and future distribution of anchovy spawning in the Bay of Biscay. Deep Sea Research Part II: Topical Studies in Oceanography 159:169-182.

Erauskin-Extramiana, M., P. Alvarez, H. Arrizabalaga, L. Ibaibarriaga, A. Uriarte, U. Cotano, M. Santos, L. Ferrer, A. Cabré, and X. Irigoien. 2019. Historical trends and future distribution of anchovy spawning in the Bay of Biscay. Deep Sea Research Part II: Topical Studies in Oceanography 159:169-182.

Goetz, S., Read, F.L., Santos, M.B., Pita, C., Pierce, G.J., 2014. Cetacean fishery interactions in Galicia (NW Spain): results and management implications of a face-to-face interview survey of local fishers. Ices J. Mar. Sci. 71, 604–617. <https://doi.org/10.1093/icesjms/fst149>

Hemery, G., D’Amico, F., Castege, I., Dupont, B., D’Elbee, J., Lalanne, Y., Mouches, C., 2007. Detecting the impact of oceano-climatic changes on marine ecosystems using a multivariate index: the case of the Bay of Biscay (North Atlantic - European Ocean). Glob. Chang. Biol. 14, 1–12. [https://doi.org/https://doi.org/10.1111/j.1365-2486.2007.01471.x](https://doi.org/https%3A//doi.org/10.1111/j.1365-2486.2007.01471.x)

Hermant, M., Lobry, J., Bonhommeau, S., Poulard, J.C., Le Pape, O., 2010. Impact of warming on abundance and occurrence of flatfish populations in the Bay of Biscay (France). J. Sea Res. 64, 45–53. <https://doi.org/10.1016/j.seares.2009.07.001>

ICES, 2020. Workshop on fisheries Emergency Measures to minimize ByCatch of short-beaked common dolphins in the Bay of Biscay and harbour porpoise in the Baltic Sea (WKEMBYC) [Draft Report]. ICES Sci. Reports 2, 344.

ICES. 2020. Road map for ICES bycatch advice on protected, endangered, and threatened species. In Report of the ICES Advisory Committee, 2020. ICES Advice 2020, section 1.6. <https://doi.org/10.17895/ices.advice.6022>

López, A., Pierce, G.J., Santos, M.B., Gracia, J., Guerra, A., 2003. Fishery by-catches of marine mammals in Galician waters: Results from on-board observations and an interview survey of fishermen. Biol. Conserv. 111, 25–40. [https://doi.org/10.1016/S0006-3207(02)00244-6](https://doi.org/10.1016/S0006-3207%2802%2900244-6)

Louzao, M., Abaroa, K., Martínez, J., Oyarzábal, I., Murillas, A. (2018) Evaluación de la interacción entre la comunidad de aves marinas y la flota artesanal de la costa vasca. Report for the IM16EBARTESA project (AZTI).

Mannocci, L., Dabin, W., Augeraud-Véron, E., Dupuy, J.F., Barbraud, C., Ridoux, V., 2012. Assessing the impact of bycatch on dolphin populations: The case of the common dolphin in the Eastern North Atlantic. PLoS One 7, e32615. <https://doi.org/10.1371/journal.pone.0032615>

McGovern, B., Culloch, R.M., O’Connell, M., Berrow, S., 2018. Temporal and spatial trends in stranding records of cetaceans on the Irish coast, 2002-2014. J. Mar. Biol. Assoc. United Kingdom 98, 977–989. <https://doi.org/10.1017/s0025315416001594>

Meier, R.E., Votier, S.C., Wynn, R.B., Guilford, T., Grive, M.M., Rodriguez, A., Newton, J., Maurice, L., Chouvelon, T., Dessier, A., Trueman, C.N., 2017. Tracking, feather moult and stable isotopes reveal foraging behaviour of a critically endangered seabird during the non-breeding season. Divers. Distrib. 23, 130–145. <https://doi.org/10.1111/ddi.12509>

Modica L, Velasco F, Preciado I, Soto M, Greenstreet SPR (2014) Development of the large fish indicator and associated target for a Northeast Atlantic fish community. ICES Journal of Marine Science 71(9) 2403–2415. <https://doi.org/10.1093/icesjms/fsu101>

Munilla, I., Díez, C., Velando, A., 2007. Are edge bird populations doomed to extinction? A retrospective analysis of the common guillemot collapse in Iberia. Biol. Conserv. 137, 359–371. <https://doi.org/10.1016/j.biocon.2007.02.023>

Peltier, H., Authier, M., Dabin, W., Dars, C., Demaret, F., Doremus, G., Van Canneyt, O., Laran, S., Mendez-Fernandez, P., Spitz, J., Daniel, P., Ridoux, V., 2020. Can modelling the drift of bycaught dolphin stranded carcasses help identify involved fisheries? An exploratory study. Glob. Ecol. Conserv. 21. <https://doi.org/10.1016/j.gecco.2019.e00843>

Peltier, H., Authier, M., Deaville, R., Dabin, W., Jepson, P.D., van Canneyt, O., Daniel, P., Ridoux, V., 2016. Small cetacean bycatch as estimated from stranding schemes: The common dolphin case in the northeast Atlantic. Environ. Sci. Policy 63, 7–18. <https://doi.org/10.1016/j.envsci.2016.05.004>

Peltier, H., Jepson, P.D., Dabin, W., Deaville, R., Daniel, P., Van Canneyt, O., Ridoux, V., 2014. The contribution of stranding data to monitoring and conservation strategies for cetaceans: Developing spatially explicit mortality indicators for common dolphins (Delphinus delphis) in the eastern North-Atlantic. Ecol. Indic. 39, 203–214. <https://doi.org/10.1016/j.ecolind.2013.12.019>

[Preciado I, Arroyo NL, González-Irusta JM, López-López L, Punzón A, Muñoz I, Serrano A (2019) Small-scale spatial variations of trawling impact on food web structure. Ecological Indicators 98, 442-452. https://doi.org/10.1016/j.ecolind.2018.11.024](https://doi.org/10.1016/j.ecolind.2018.11.024)

Punzón A, Villamor B (2009) Does the timing of the spawning migration change for the southern component of the Northeast Atlantic Mackerel (Scomber scombrus, L. 1758)? An approximation using fishery analyses. Continental Shelf Research 29(8), 1195-1204. <https://doi.org/10.1016/j.csr.2008.12.024>

Punzón, A., Serrano, A., Sánchez, F., Velasco, F., Preciado, I., González-Irusta, J.M., López-López, L., 2016. Response of a temperate demersal fish community to global warming. J. Mar. Syst. 161, 1–10. <https://doi.org/10.1016/j.jmarsys.2016.05.001>

Ravard, D., Brind’Amour, A., Trenkel, V.M., 2014. Evaluating the potential impact of fishing on demersal species in the Bay of Biscay using simulations and survey data. Fish. Res. 157, 86–95. <https://doi.org/10.1016/j.fishres.2014.03.007>

Read, F.L., Evans, P.G.H., Dolman, S.J., 2017. Cetacean Bycatch Monitoring and Mitigation under EC Regulation 812/2004 in the Northeast Atlantic, North Sea and Baltic Sea from 2006 to 2014 68.

Silva, A., S. Garrido, L. Ibaibarriaga, L. Pawlowski, I. Riveiro, V. Marques, F. Ramos, E. Duhamel, M. Iglesias, P. Bryère, A. Mangin, L. Citores, P. Carrera, and A. Uriarte. 2019. Adult-mediated connectivity and spatial population structure of sardine in the Bay of Biscay and Iberian coast. Deep Sea Research Part II: Topical Studies in Oceanography 159:62-74.

Silva, A., S. Garrido, L. Ibaibarriaga, L. Pawlowski, I. Riveiro, V. Marques, F. Ramos, E. Duhamel, M. Iglesias, P. Bryère, A. Mangin, L. Citores, P. Carrera, and A. Uriarte. 2019. Adult-mediated connectivity and spatial population structure of sardine in the Bay of Biscay and Iberian coast. Deep Sea Research Part II: Topical Studies in Oceanography 159:62-74.

Soriano-Redondo, A., Cortés, V., Reyes-González, J.M., Guallar, S., Bécares, J., Rodríguez, B., Arcos, J.M., González-Solís, J., 2016. Relative abundance and distribution of fisheries influence risk of seabird bycatch. Sci. Rep. 6, 37373. <https://doi.org/10.1038/srep37373>

Tasker, M.L., 2008. The effect of climate change on the distribution and abundance of marine species in the OSPAR Maritime Area. ICES Cooperative Research Report No 293.

**DTU**

Berge, J., Heggland, K., Lønne, O. J., Cottier, F., Hop, H., Gabrielsen, G. W., ... & Misund, O. A. (2015). First records of Atlantic mackerel (*Scomber scombrus*) from the Svalbard archipelago, Norway, with possible explanations for the extensions of its distribution. Arctic, 54-61.

Bergstad, O.A., Wik Å.D. and Hildre Ø. 2000. Predator-prey relationships and food sources of the Skagerrak deep-water fish assemblage. J. Northw. Atl. Fish. Sci. 31:165-180.

Christensen-Dalsgaard, S., Anker-Nilssen, T., Crawford, R., Bond, A., Sigurðsson, G. M., Glemarec, G., ... & Merkel, F. R. (2019). What’s the catch with lumpsuckers? A North Atlantic study of seabird bycatch in lumpsucker gillnet fisheries. Biological Conservation, 240, 108278.

Clausen, L. W., Rindorf, A., van Deurs, M., Dickey‐Collas, M., & Hintzen, N. T. (2018). Shifts in North Sea forage fish productivity and potential fisheries yield. *Journal of Applied Ecology*, *55*(3), 1092-1101.

Eigaard, O. R., Bastardie, F., Breen, M., Dinesen, G. E., Hintzen, N. T., Lafargue, P., ... & Rijnsdorp, A. D. (2016). Estimating seabed pressure from demersal trawls, seines, and dredges based on gear design and dimensions. ICES Journal of Marine Science, 73(Suppl. 1), 27-43. https://doi.org/10.1093/icesjms/fsv099

Engelhard, G. H., Peck, M. A., Rindorf, A., C. Smout, S., van Deurs, M., Raab, K., ... & Brunel, T. (2014). Forage fish, their fisheries, and their predators: who drives whom?. ICES Journal of Marine Science, 71(1), 90-104.

Glemarec, G., Kindt-Larsen, L., Lundgaard, L. S., & Larsen, F. (2020). Assessing seabird bycatch in gillnet fisheries using electronic monitoring. Biological Conservation, 243, 108461.

Gröger, J. P., Hinrichsen, H. H., & Polte, P. (2014). Broad-scale climate influences on spring-spawning herring (*Clupea harengus*, L.) recruitment in the Western Baltic Sea. PloS one, 9(2).

Moll, D., Kotterba, P., von Nordheim, L., & Polte, P. (2018). Storm-induced Atlantic herring (*Clupea harengus*) egg mortality in Baltic Sea inshore spawning areas. Estuaries and coasts, 41(1), 1-12.

Henriksen, O., Christensen, A., Jónasdóttir, S., MacKenzie, B. R., Nielsen, K. E., Mosegård, H., & van Deurs, M. (2018). Oceanographic flow regime and fish recruitment: reversed circulation in the North Sea coincides with unusually strong sandeel recruitment. Marine Ecology Progress Series, 607, 187-205.

Lindegren, M., Van Deurs, M., MacKenzie, B. R., Worsoe Clausen, L., Christensen, A., & Rindorf, A. (2018). Productivity and recovery of forage fish under climate change and fishing: North Sea sandeel as a case study. Fisheries Oceanography, 27(3), 212-221.

ICES WKSPRAT REPORT (2018). ICESCM 2018/ACOM:35

ICES WKSAND REPORT (2016). ICES CM 2016/ACOM:33

ICES 2019a WGWIDE Scientific Report. 1:36. 948 pp. http://doi.org/10.17895/ices.pub.5574

Nikolioudakis, N., Skaug, H. J., Olafsdottir, A. H., Jansen, T., Jacobsen, J. A., & Enberg, K. (2019). Drivers of the summer-distribution of Northeast Atlantic mackerel (*Scomber scombrus*) in the Nordic Seas from 2011 to 2017; a Bayesian hierarchical modelling approach. ICES Journal of Marine Science, 76(2), 530-548.

ICES 2019b WGNSSK scientific Report. 1:7. 1271 pp. http://doi.org/10.17895/ices.pub.5402

Eigaard, O. R., Herrmann, B., & Nielsen, J. R. (2012). Influence of grid orientation and time of day on grid sorting in a small-meshed trawl fishery for Norway pout *(Trisopterus esmarkii*). Aquatic Living Resources, 25(1), 15-26.

ICES. 2017. Report on the Long-term Management Strategy Evaluation for Northern Shrimp (*Pandalus borealis*) in Division 4.a East and Subdivision 20 (PandLTMS). October–November 2017, ICES CM 2017/ACOM:52. 182 pp.

ICES. 2020a. Joint NAFO/ICES Pandalus Assessment Working Group (NIPAG). ICES Scientific Reports. 2:19. 22 pp. http://doi.org/10.17895/ices.pub.5554

ICES. 2020b. Working Group on Fisheries Benthic Impact and Trade-offs (WGFBIT; outputs from 2019 meeting). ICES Scientific Reports. 2:6. 101 pp. http://doi.org/10.17895/ices.pub.5955

Kindt-Larsen, L., Berg, C. W., Tougaard, J., Sørensen, T. K., Geitner, K., Northridge, S., ... & Larsen, F. (2016). Identification of high-risk areas for harbour porpoise *Phocoena phocoena* bycatch using remote electronic monitoring and satellite telemetry data. Marine Ecology Progress Series, 555, 261-271.

Project-PELA supported by the European Maritime and Fisheries Fund (EMFF) and the Ministry of Environment and Food of Denmark (project id: 33113-B-19-154); ending 20. March 2022

Project-NORDMAK supported by the European Maritime and Fisheries Fund (EMFF) and the Ministry of Environment and Food of Denmark (project id: 33113-B-17-098); ending 7. December 2020

Project-TRUST supported by the European Maritime and Fisheries Fund (EMFF) and the Ministry of Environment and Food of Denmark (project id: 33112-P-19-062 ); ending 22. April 2022

Project-EASIMAC supported by the European Maritime and Fisheries Fund (EMFF) and the Ministry of Environment and Food of Denmark (project id: 33112-P-19-066); ending 27. March 2022

[ICES Working group held in February 2020: https://www.ices.dk/community/groups/Pages/WKREBUILD.aspx](https://www.ices.dk/community/groups/Pages/WKREBUILD.aspx)

Rijnsdorp, A. D., Hiddink, J. G., van Denderen, P. D., Hintzen, N. T., Eigaard, O. R., Valanko, S., ... & van Kooten, T. (Accepted/In press). Different bottom trawl fisheries have a differential impact on the status of the North Sea seafloor habitats. ICES Journal of Marine Science, [fsaa050]. https://doi.org/10.1093/icesjms/fsaa050

Wright, P. J., Christensen, A., Régnier, T., Rindorf, A., & van Deurs, M. (2019). Integrating the scale of population processes into fisheries management, as illustrated in the sandeel, *Ammodytes marinus*. ICES Journal of Marine Science, 76(6), 1453-1463.

Ziegler, F., Hornborg, S., Valentinsson, D., Hognes, E. S., Søvik, G., and Eigaard, O. R. (2016) Same stock, different management: quantifying the sustainability of three shrimp fisheries in the Skagerrak from a product perspective. ICES Journal of Marine Science 73(7), 1806–1814. doi:10.1093/icesjms/fsw0351806–1814.

**BIOR**

Arula, T.; Raid, T.; Simm, M.; Ojaveer, H. (2016). Temperature-driven changes in early life-history stages influence the Gulf of Riga spring spawning herring (*Clupea harengus* m.) recruitment abundance. Hydrobiologia, 767 (1), 125−135.10.1007/s10750-015-2486-8.

HELCOM (2018): State of the Baltic Sea – Second HELCOM holistic assessment 2011-2016. Baltic Sea Environment Proceedings 155.

ICES. 2014. Bycatch of small cetaceans and other marine animals – Review of national reports under Council Regulation (EC) No. 812/2004 and other published documents. In Report of the ICES Advisory Committee, 2014. ICES Advice 2014, section 1.6.1.1. 8 pp. https://doi.org/10.17895/ices.advice.5651

ICES. 2019. Baltic Sea Ecosystem – Fisheries Overview. In Report of the ICES Advisory Committee, 2019. ICES Advice 2019, section 4.2. 28 pp. https://doi.org/10.17895/ices.advice.XXXX

Neuenfeldt, S., Bartolino, V., Orio, A., Andersen, K.H., Andersen, N.G., Niiranen, S., Bergström, U., Ustups, D. Kallasvuo, M., Kulatska, N. and Casini, M. (2020). Feeding and growth of Atlantic cod (*Gadus morhua* L.) in the Eastern Baltic Sea under environmental change. ICES Journal of Marine Science, 77: 624–632.

Margonski, P., Hansson, S., Tomczak, M., & Grzebielec, R. (2010). Climate influence on Baltic cod, sprat, and herring stock–recruitment relationships. Progress in Oceanography, 87(1-4), 277-288. https://doi.org/10.1016/j.pocean.2010.08.003

Plikshs, M., Hinrichsen, H.H., Elferts, D., Sics, I., Kornilovs, G., Koster, F.W. 2015. "Reproduction of Baltic cod, *Gadus morhua* (Actinopterygii: Gadiformes: Gadidae), in the Gotland Basin: Causes of annual variability," Acta Ichthyologica et Piscatoria, vol. 45, no. 3, pp. 247-258.

PUNTILA, R., STRAKE, S., FLORIN, A.-B., NADDAFI, R., LEHTINIEMI, M., BEHRENS, J. W., KOTTA, J., OESTERWIND, D., PUTNIS, I., SMOLINSKI, S., WOZNICZKA, A., OJAVEER, H., LOŽYS, L., USPENSKIY, A. & YURTSEVA, A. 2018. Abundance and distribution of round goby (*Neogobius melanostomus*). [Online]. Available: https://helcom.fi/baltic-sea-trends/environment-fact-sheets/biodiversity/abundance-and-distribution-of-round-goby/

Ustups, D., Mueller-Karulis, B., Bergstrom, U., Makarchouk, A., Sics, I. 2013. "The influence of environmental conditions on early life stages of flounder (*Platichthys flesus*) in the central Baltic Sea," Journal of Sea Research, vol. 75, pp. 77-84. DOI: 10.1016/j.seares.2015.06.021

Ustups, D., Bergstrom, U., Florin, A.B., Kruze, E., Zilniece, D., Elferts, D., Knospina, E., Uzars, D. 2016. "Diet overlap between juvenile flatfish and the invasive round goby in the central Baltic Sea," Journal of Sea Research, vol. 107, pp. 121-129. https://doi.org/10.1016/j.seares.2015.06.021

**IEO**

Cervantes A, Faraj A, Enthoven L (2018) Rapport de la Réunion Scientifique Conjointe annuelle relative à l'Accord de pêche signé entre le Royaume du Maroc et l'Union européenne. Madrid, Espagne, 24-26 septembre 2018. Rapports des Comités Scientifiques Conjoints. Bruxelles, 88p.

Carvalho-Souza GF, González-Ortegón E, Baldó F, Vilas C, Drake P, Llope M (2019) Natural and anthropogenic drivers on the early life stages of European anchovy in one of its Essential Fish Habitats, the Guadalquivir estuary. Marine Ecology Progress Series 617-618: 67–79. https://doi.org/10.3354/meps12562

EEMM (2012) Evaluación inicial y buen estado ambiental. Grupo de mamíferos marinos. Ministerio de Agricultura, Alimentación y Medio Ambiente. Madrid.

EEMM (2012) Estrategias Marinas: evaluación inicial, buen estado ambiental y objetivos ambientales. Ministerio de Agricultura, Alimentación y Medio Ambiente. Madrid.

ECOFISH: ECO-innovative strategies for a sustainable fishery in the SPA of the Gulf of Cadiz. https://www.programapleamar.es/proyectos/ecofish-estrategias-eco-innovadoras-para-una-pesqueria-sostenible-en-la-zepa-del-golfo-de

Gamaza MA (2019) Managing multi-species trawl fisheries in southern Europe for biological and economic sustainability the Gulf of Cadiz case study. PhD thesis.

García-Isarch E, Millán M, Ramos F, Santamaría MTG, Burgos C (2012) Recent past and present of the Spanish fishery of anchovy (*Engraulis encrasicolus* Linnaeus, 1758) in Atlantic Moroccan waters. In: S.

Garcia, M. Tandstad and A.M. Caramelo (eds.). Science and Management of Small Pelagics. Symposium on Science and the Challenge of Managing Small Pelagic Fisheries on Shared Stocks in Northwest Africa, 11–14 March 2008, Casablanca, Morocco. FAO Fisheries and Aquaculture Proceedings. No. 18. Rome, FAO. 441–449.

ICES (2019a) Request from Portugal and Spain to evaluate a management and recovery plan for the Iberian sardine stock (divisions 8.c and 9.a). In Report of the ICES Advisory Committee. ICES Advice 2019, sr.2019.10, https://doi.org/10.17895/ices.advice.5275

ICES (2019b) Workshop on the Iberian Sardine Management and Recovery Plan (WKSARMP). ICES Scientific Reports. 1:18. 168 pp. http://doi.org/ 10.17895/ices.pub.5251

Llope M (2017) The ecosystem approach in the Gulf of Cadiz. A perspective from the southernmost European Atlantic regional sea. ICES Journal of Marine Science 74, 382-390. https://doi.org/10.1093/icesjms/fsw165

Stratoudakis Y, Marçalo A (2002) Sardine slipping during purse-seining off northern Portugal
ICES Journal of Marine Science 59(6): 1256–1262. https://doi.org/10.1006/jmsc.2002.1314

Torres MA, Coll M, Heymans JJ, Christensen V, Sobrino I (2013) Food-web structure of and fishing impacts on the Gulf of Cadiz ecosystem (South-western Spain). Ecological Modelling 265: 26–44. https://doi.org/10.1016/j.ecolmodel.2013.05.019

VENUS project. Ref. 0139\_VENUS\_5\_E. (2017-2019). Estudio Integral de los bancos naturales de moluscos bivalvos en el Golfo de Cádiz para su gestión sostenible y la conservación de sus hábitats asociados. Interreg V-A España- Portugal 2014-2020 (POCTEP) https://www.project-venus.com/

VORATUN project. CTM2017-82808-R: Study of blackspot seabream-bluefin tuna interactions in the food web of the Strait of Gibraltar with analysis of stomach contents and stable isotopes: Impact on fisheries

**ILVO**

Bekaert, K., Devriese, L., Vandendriessche, S., and Vanderperren, E. 2015. Spekvis – op zoek naar duurzame alternatieven voor spekking. ILVO MEDEDELING 192. 54 pp. http://www.ilvo.vlaanderen.be/Portals/68/documents/Mediatheek/Mededelingen/192\_spekvis.pdf

Bergman, M. J. N. & E. H. Meesters, 2020. First indications for reduced mortality of non-target invertebrate benthic megafauna after pulse beam trawling. ICES Journal of Marine Science doi:10.1093/icesjms/fsz250.

Depestele, J., Degrendele, K., Esmaeili, M., Ivanović, A., Kröger, S., O’Neill, F. G., Parker, R., et al. 2018. Comparison of mechanical disturbance in soft sediments due to tickler-chain SumWing trawl vs. electro-fitted PulseWing trawl. ICES Journal of Marine Science, 76: 312-329.

Depestele, J., Ivanovic, A., Degrendele, K., Esmaeili, M., Polet, H., Roche, M., Summerbell, K., et al. 2016. Measuring and assessing the physical impact of beam trawling. ICES Journal of Marine Science, 73: i15-i26.

Depestele, J., M. Desender, H. P. Benoît, H. Polet & M. Vincx, 2014. Short-term survival of discarded target fish and non-target invertebrate species in the "eurocutter" beam trawl fishery of the southern North Sea. Fisheries Research 154(0):82-92 doi:http://dx.doi.org/10.1016/j.fishres.2014.01.018.

Depestele, J., Polet, H., Stouten, H., Van Craeynest, K., Vanderperren, E., and Verschueren, B. 2007. Is there a way out for the beam trawler fleet with rising fuel prices? . In ICES Annual Science Conference. ICES CM 2007/ M:06, Marina Congress Center, Helsinki, Finland.

Fonteyne, R., 2000. Physical impact of beam trawls on seabed sediments. In Kaiser, M. J. & S. J. de Groot (eds) The effects of fishing on non-target species and habitats: biological, conservation and socio-economic issues. Fishing News Books, 15-36.

Heessen, H. J. L. & N. Daan, 1996. Long-term trends in ten non-target North Sea fish species. ICES Journal of Marine Science 53(6):1063-1078 doi:10.1006/jmsc.1996.0133.

Hoarau, G., E. Boon, D. N. Jongma, S. Ferber, J. Palsson, H. W. V. d. Veer, A. D. Rijnsdorp, W. T. Stam & J. L. Olsen, 2005. Low effective population size and evidence for inbreeding in an overexploited flatfish, plaice (*Pleuronectes platessa* L.). Proceedings of the Royal Society B: Biological Sciences 272(1562):497-503 doi:doi:10.1098/rspb.2004.2963.

ICES. 2019. Report of the Working Group on Crangon Fisheries and Life History (WGCRAN), 9–11 October 2019, ICES Headquarters, Copenhagen, Denmark. ICES CM 2018/EPDSG:06. 68 pp.

ICES. 2019. Working Group on the Assessment of Demersal Stocks in the North Sea and Skagerrak (WGNSSK). ICES Scientific Reports. 1:7 1271 pp.

Mengual, B., Cayocca, F., Le Hir, P., Draye, R., Laffargue, P., Vincent, B., and Garlan, T. 2016. Influence of bottom trawling on sediment resuspension in the ‘Grande-Vasière’ area (Bay of Biscay, France). Ocean Dynamics, 66: 1181-1207.

Mensink, B. P., Everaarts, J. M., Kralt, H., ten Hallers-Tjabbes, C. C., and Boon, J. P. 1996. Tributyltin exposure in early life stages induces the development of male sexual characteristics in the common whelk, *Buccinum undatum*. Marine Environmental Research, 42: 151-154.

Mollet, F. M., Kraak, S. B. M., and Rijnsdorp, A. D. 2007. Fisheries-induced evolutionary changes in maturation reaction norms in North Sea sole *Solea solea*. Marine Ecology Progress Series, 351: 189-199.

Nehring, S. After the TBT era: Alternative anti-fouling paints and their ecological risks. Senckenbergiana maritima 31, 341 (2001). https://doi.org/10.1007/BF03043043

Paschen, M., U. Richter & W. Köpnick, 1999. Trawl Penetration in the Seabed (TRAPESE). Draft Final Report EC-Study Contract No 96-006. University of Rostock, Rostock, Germany, 150pp.

Perry, A. L., Low, P. J., Ellis, J. R., and Reynolds, J. D. 2005. Climate Change and Distribution Shifts in Marine Fishes. Science, 308: 1912-1915.

Rijnsdorp, A. D., J. G. Hiddink, P. D. van Denderen, N. T. Hintzen, O. R. Eigaard, S. Valanko, F. Bastardie, S. G. Bolam, P. Boulcott, J. Egekvist, C. Garcia, G. van Hoey, P. Jonsson, P. Laffargue, J. R. Nielsen, G. J. Piet, M. Sköld & T. van Kooten, 2020. Different bottom trawl fisheries have a differential impact on the status of the North Sea seafloor habitats. ICES Journal of Marine Science doi:10.1093/icesjms/fsaa050.

SALV, 2020. Een duurzaam akkoord voor de Vlaamse visserij post-brexit. SALV report, Brussel, 29pp. https://www.salv.be/sites/default/files/documenten/SALV\_20200124\_ADV\_2020-01\_Brexit.pdf

Schulte, K. F., Dänhardt, A., Hufnagl, M., Siegel, V., Wosniok, W., and Temming, A. 2018. Not easy to catch: multiple covariates influence catch rates of brown shrimp (*Crangon crangon* L.), potentially affecting inferences drawn from catch and landings data. ICES Journal of Marine Science: fsx203-fsx203.

Sciberras, M., Tait, K., Brochain, G., Hiddink, J. G., Hale, R., Godbold, J. A., and Solan, M. 2017. Mediation of nitrogen by post-disturbance shelf communities experiencing organic matter enrichment. Biogeochemistry, 135: 135-153.

Siegel, V., GrÖGer, J., Neudecker, T., Damm, U., and Jansen, S. 2005. Long-term variation in the abundance of the brown shrimp *Crangon crangon* (L.) population of the German Bight and possible causes for its interannual variability. Fisheries Oceanography, 14: 1-16.

Sobrino Heredia, J M, 2017, Research for PECH Committee – Common Fisheries Policy and BREXIT - Legal framework for governance, European Parliament, Policy Department for Structural and Cohesion Policies, Brussels

Stäbler, M., Kempf, A., Mackinson, S., Poos, J. J., Garcia, C., and Temming, A. 2016. Combining efforts to make maximum sustainable yields and good environmental status match in a food-web model of the southern North Sea. Ecological modelling 331, 17-30

Sys, K., Poos, J. J., Van Meensel, J., Polet, H., and Buysse, J. 2016. Competitive interactions between pulse and beam trawlers in the North Sea. ICES Journal of Marine Science, 73: 1485-1493.

Teal, L. R., van Hal, R., van Kooten, T., Ruardij, P., and Rijnsdorp, A. D. 2012. Bio-energetics underpins the spatial response of North Sea plaice (*Pleuronectes platess*a L.) and sole (*Solea solea* L.) to climate change. Global Change Biology, 18: 3291-3305.

Temming, A., and Hufnagl, M. 2015. Decreasing predation levels and increasing landings challenge the paradigm of non-management of North Sea brown shrimp (*Crangon crangon*). ICES Journal of Marine Science: Journal du Conseil, 72: 804-823.

Temming, A., Günther, C., Rückert, C., and Hufnagl, M. 2017. Understanding the life cycle of North Sea brown shrimp *Crangon crangon*: a simulation model approach. Marine Ecology Progress Series, 584: 119-143.

Tiano, J. C., K. J. van der Reijden, S. O'Flynn, O. Beauchard, S. van der Ree, J. van der Wees, T. Ysebaert & K. Soetaert, 2020. Experimental bottom trawling finds resilience in large-bodied infauna but vulnerability for epifauna and juveniles in the Frisian Front. Mar Environ Res:104964 doi:https://doi.org/10.1016/j.marenvres.2020.104964.

Ulrich, C. 2018. Landing Obligation and Choke species in multispecies and mixed fisheries - the North Sea. European Parliament, Policy Department for Structural and Cohesion Policies. Research for PECH Committee, Brussels

van Denderen, P. D., van Kooten, T., and Rijnsdorp, A. D. 2013. When does fishing lead to more fish? Community consequences of bottom trawl fisheries in demersal food webs. Proceedings of the Royal Society B: Biological Sciences, 280.

van der Molen, J., Aldridge, J., Coughlan, C., Parker, E., Stephens, D., and Ruardij, P. 2013. Modelling marine ecosystem response to climate change and trawling in the North Sea. Biogeochemistry, 113: 213-236.

Vercauteren, M, Decostere, A, Chiers, K. First report of lesions resembling red mark syndrome observed in wild‐caught common dab (*Limanda limanda* ). J Fish Dis. 2020; 43: 147– 151. https://doi.org/10.1111/jfd.13104

Verhaegen, Y., Monteyne, E., Neudecker, T., Tulp, I., Smagghe, G., Cooreman, K., Roose, P., et al. 2012. Organotins in North Sea brown shrimp (*Crangon crangon* L.) after implementation of the TBT ban. Chemosphere, 86: 979-984.

Walker, N. D., B. García-Carreras, W. J. F. Le Quesne, D. L. Maxwell & S. Jennings, 2019. A data-limited approach for estimating fishing mortality rates and exploitation status of diverse target and non-target fish species impacted by mixed multispecies fisheries. ICES Journal of Marine Science doi:10.1093/icesjms/fsy205.

Ziegler, F., and Hornborg, S. 2014. Stock size matters more than vessel size: The fuel efficiency of Swedish demersal trawl fisheries 2002-2010. Marine Policy, 44: 72-81.

**NMFRI**

Anon. 2019. The future of offshore wind in Poland. PWEA Report. May 2019.

Carstensen,J., Andersen,J.H., Gustafsson,B.G., and Conley,D.J. 2014. Deoxygenation of the Baltic Sea during the last century .Proceedings of the National Academy of Sciences, 111: 5628–5633.

Eero, M., Vinther, M., Haslob, H., Bastian Huwer, B., Casini, M., Marie Storr-Paulsen, M., & Koster, F.W. 2012. Spatial management of marine resources can enhance the recovery of predators and avoid local depletion of forage fish. Conservation Letters 5 (2012) doi: 10.1111/j.1755-263X.2012.00266.x486–492

Horbowy J, Podolska M, Nadolna-Altyn K. 2016. Increasing occurrence of anisakid nematodes in the liver of cod (*Gadus morhua*) from the Baltic Sea: Does infection affect the condition and mortality of fish? Fisheries Research 179: 98-103.

Hinrichsen, H-H.,Huwer, B., Makarchouk, A.,Petereit, C., Schaber, M., and Voss, R. 2011. Climate-driven long-term trends in Baltic Sea oxygen concentrations and the potential consequences for eastern Baltic cod (*Gadus morhua*). ICES Journal of Marine Science, 68: 2019–2028.

Haarder, S., Kania, P. W., Galatius, A., and Buchmann, K. 2014. Increased Contracaecum osculatum infection in Baltic cod (*Gadus morhua*) livers (1982–2012) associated with increasing grey seal (*Halichoerus gryphus*) populations. Journal of Wildlife Diseases, 50: 537–543.

Koster, F.W., Vinther, M., MacKenzie, B. R., Eero, M., and Plikshs, M.2009. Environmental effects on recruitment and implications for biological reference points of eastern Baltic cod (*Gadus morhua*). Journal of Northwest Atlantic Fishery Science, 41: 205–220.

ICES. 2020. Report on eastern Baltic cod bycatch in non-targeted fisheries, mixing with western Baltic cod in SD24, and stock situation in SDs 27-32 (Ad hoc). ICES Scientific Reports. 1:76. 69 pp. http://doi.org/10.17895/ices.pub.5635

Neumann,V.,Koster, F.W., Schaber, M., and Eero,M. 2014.Recovery in eastern Baltic cod: Is increased recruitment caused by decreased predation on early life stages? ICES Journal of Marine Science, 71: 1382–1392.

Nadolna, K., and Podolska, M. 2014. Anisakid larvae in the liver of cod (*Gadus morhua* L.) from the Southern Baltic Sea. Journal of Helminthology, 88: 237–246.

**TI**

Acoura Marine Ltd. (2017). *MSC Sustainable Fisheries Certification. North Sea Brown Shrimp* Public Certification Report. Marine Stewardship Council.

BSH, (Bundesamt für Seeschifffahrt und Hydrographie ). (2020). *Statusbericht zur Fortschreibung der Raumordnungspläne für die deutsche ausschließliche Wirtschaftszone in der Nord- und Ostsee*. Hamburg and Rostock:

Buck, Bela H., Ebeling, Michael W., Michler-Cieluch, Tanja. (2010). MUSSEL CULTIVATION AS A CO-USE IN OFFSHORE WIND FARMS: POTENTIAL AND ECONOMIC FEASIBILITY. *Aquaculture Economics & Management* 14/4: 255-281.

Doering, R. , Kempf, A., Belschner, T., Berkenhagen, J., Bernreuther, M., Hentsch, S., Kraus, G. et al. (2017). *Research for PECHCommittee –BREXIT Consequences for the Common Fisheries Policy-Resources and Fisheries - a Case Study*. Brussels: P. D. f. S. a. C. P. European Parliament.

Engelhard, Georg H., Pinnegar, John K., Kell, Laurence T., Rijnsdorp, Adriaan D. (2011). Nine decades of North Sea sole and plaice distribution. *ICES Journal of Marine Science* 68/6: 1090-1104.

Gimpel, A., Stelzenmüller, V., Haslob, H., Berkenhagen, J., Schupp, M.F., Krause, G. , Buck, B.H. (2020). *Off shore-Windparks: Chance für Fischerei und Naturschutz*. Braunschweig: J. H. v. Thünen-Institut.

Hanel, R., Briand, C., Diaz, E., Döring, R., Sapounidis, A., Warmerdam, W., Andrés, M. et al. (2019). *Research for PECH Committee – Environmental, social and economic sustainability of European eel management*. Brussels: P. D. f. S. a. C. P. European Parliament.

Hyder, Kieran, Weltersbach, Marc Simon, Armstrong, Mike, Ferter, Keno, Townhill, Bryony, Ahvonen, Anssi, Arlinghaus, Robert et al. (2018). Recreational sea fishing in Europe in a global context—Participation rates, fishing effort, expenditure, and implications for monitoring and assessment. *Fish and Fisheries* 19/2: 225-243.

ICES. (2018). *European eel (Anguilla anguilla) throughout its natural range*. ICES Advice on fishing opportunities, catch, and effort. Ecoregions in the Northeast Atlantic. ele.2737.nea.

ICES. (2017). *Report of the ICES/PICES Workshop on Regional climate change vulnerability assessment for the large marine ecosystems of the northern hemisphere (WKSICCME-CVA)*. 2017/SSGEPD:23. Copenhagen:

J., Baer, A., Smaal, van der Reijden, K., Nehls, G. (2017). *Fisheries. In: Wadden Sea*. Quality Status Report 2017. Wilhelmshaven, Germany: C. W. S. Secretariat. https://qsr.waddensea-worldheritage.org/reports/fisheries.

Königson, Sara, Lövgren, Johan, Hjelm, Joakim, Ovegård, Mikael, Ljunghager, Fredrik, Lunneryd, Sven-Gunnar. (2015). Seal exclusion devices in cod pots prevent seal bycatch and affect their catchability of cod. *Fisheries Research* 167: 114-122.

LUNG, (Landesamt für Umwelt, Naturschutz und Geologie Mecklenburg-Vorpommern). (2018). *Statusbericht zur Kegelrobbe in den Küstengewässern von Mecklenburg-Vorpommern*. Güstrow:

Strehlow, Harry V., Schultz, Norbert, Zimmermann, Christopher, Hammer, Cornelius. (2012). Cod catches taken by the German recreational fishery in the western Baltic Sea, 2005–2010: implications for stock assessment and management. *ICES Journal of Marine Science* 69/10: 1769-1780.

Waldo, Staffan, Paulrud, Anton, Blomquist, Johan. (2019). *The Economic Costs of Seal Presence in Swedish Small-Scale Fisheries*. Lund: A. E. Centre. www.agrifood.se/Files/AgriFood\_WP20192.pdf.

**WUR**

Bartule, I., and O. Adamenko. 2017. New things in fisheries regulation in Latvian). Latvian Fisheries Yearbook 2017. The Latvian Rural Advisory and Training Centre, 185 p.(Strehlow et al. 2012, Königson et al. 2015, Hyder et al. 2018, ICES 2018, LUNG 2018, Hanel et al. 2019, Waldo et al. 2019)

Neudecker T, Damm U (2010) The by-catch situation in German brown shrimp (*Crangon crangon* L.) fisheries with particular reference to plaice (*Pleuronectes platessa* L.). Journal of Applied Ichthyology 26: S.67-(Buck et al. 2010, Acoura Marine Ltd 2017, Doering et al. 2017, J. et al. 2017, BSH 2020,

Gimpel et al. 2020

Röckmann, C., Quirijns, F., van Overzee, H. & Uhlmann, S. (2011). Discards in fisheries – a summary of three decades of research at IMARES an(Engelhard et al. 2011, ICES 2017)d LEI. C068/11. IMARES, Wageningen. 41 S.

Barbut, L., Vastenhoud, B., Vigin, L., Degraer, S., Volckaert, F. A. M., and Lacroix, G. 2020. The proportion of flatfish recruitment in the North Sea potentially affected by offshore windfarms. ICES Journal of Marine Science, 77: 1227–1237.

Bartelings, H., and Smeets Kristkova, Z. 2018. Impact of hard Brexit on European fisheries: Scenario analysis using the MAGNET model. SUCCESS project. Wageningen University & Research, p. 28.

Baudron, A. R., Brunel, T., Blanchet, M., Hidalgo, M., Chust, G., Brown, E. J., Kleisner, K. M., et al. 2020. Changing fish distributions challenge the effective management of European fisheries. Ecography: 1–12.

Beare, D. J., Burns, F., Greig, A., Jones, E. G., Peach, K., Kienzle, M., McKenzie, E., et al. 2004. Long-term increases in prevalence of North Sea fishes having southern biogeographic affinities. Marine Ecology Progress Series, 284: 269–278.

Beare, D., Rijnsdorp, A. D., Blaesberg, M., Damm, U., Egekvist, J., Fock, H., Kloppmann, M., et al. 2013. Evaluating the effect of fishery closures: Lessons learnt from the Plaice Box. Journal of Sea Research, 84: 49–60.

Bergman, M. J. N., and Van Santbrink, J. W. 2000. Mortality in megafaunal benthic populations caused by trawl fisheries on the Dutch continental shelf in the North Sea in 1994. ICES Journal of Marine Science, 57: 1321–1331.

Borges, L., Van Keeken, O. A., Van Helmond, A. T. M., Couperus, B., and Dickey-Collas, M. 2008. What do pelagic freezer-trawlers discard? ICES Journal of Marine Science, 65: 605–611.

Brown, J., and Macfadyen, G. 2007. Ghost fishing in European waters: Impacts and management responses. Marine Policy, 31: 488–504.

Brunel, T., Piet, G. J., Van Hal, R., and Röckmann, C. 2010. Performance of harvest control rules in a variable environment. ICES Journal of Marine Science, 67: 1051–1062.

Brunel, T., van Damme, C. J. G., Samson, M., and Dickey-Collas, M. 2018. Quantifying the influence of geography and environment on the northeast Atlantic mackerel spawning distribution. Fisheries Oceanography, 27: 159–173.

Cardoso, J. F. M. F., Freitas, V., Quilez, I., Jouta, J., Witte, J. I., and Van Der Veer, H. W. 2015. The European sea bass *Dicentrarchus labrax* in the Dutch Wadden Sea: From visitor to resident species. Journal of the Marine Biological Association of the United Kingdom, 95: 839–850.

Clean Nordic Oceans. 2020. Clean Nordic Oceans - A network to reduce marine litter and ghost fishing. Nordic Council of Ministers.

Cook, R. M., and Heath, M. R. 2005. The implications of warming climate for the management of North Sea demersal fisheries. ICES Journal of Marine Science, 62: 1322–1326.

Couperus, A.S. 2018. Annual report on the implementation of Council Regulation (EC) No 812/2004 – 2017. Stichting Wageningen Research Centre for Fisheries Research (CVO). CVO report: 18.019. 16 p.

Couperus, A.S. 2019. Annual report on the implementation of Council Regulation (EC) No 812/2004 – 2018. Stichting Wageningen Research Centre for Fisheries Research (CVO). CVO report: 19.021. 18 p.

CRANIMPACT Project Website. Impact of brown shrimp fishery on benthic habitats. https://www.thuenen.de/en/sf/projects/impact-of-brown-shrimp-fishery-on-benthic-habitats-cranimpact/.

Dankel, D., Haraldsson, G., Heldbo, J., Hoydal, K., Lassen, H., Siegstad, H., Schou, M., et al. 2015. Allocation of Fishing Rights in the NEA. Discussion paper. TemaNord 2015:546. 88 p.

Daskalov, G. M., Grishin, A. N., Rodionov, S., and Mihneva, V. 2007. Trophic cascades triggered by overfishing reveal possible mechanisms of ecosystem regime shifts. Proceedings of the National Academy of Sciences, 104: 10518–10523.

de Jong, M. F., Borsje, B. W., Baptist, M. J., van der Wal, J. T., Lindeboom, H. J., and Hoekstra, P. 2016. Ecosystem-based design rules for marine sand extraction sites. Ecological Engineering, 87: 271–280.

van Denderen, P.D. 2015. Ecosystem Effects of Bottom Trawl Fishing. Wageningen University. PhD thesis. 182 pp.

Dickey-Collas, M., Engelhard, G. H., Rindorf, A., Raab, K., Smout, S., Aarts, G., van Deurs, M., et al. 2013. Ecosystem-based management objectives for the North Sea: riding the forage fish rollercoaster. ICES Journal of Marine Science, 70: 1319–1329.

Dulvy, N. K., Rogers, S. I., Jennings, S., Stelzenmüller, V., Dye, S. R., and Skjoldal, H. R. 2008. Climate change and deepening of the North Sea fish assemblage: A biotic indicator of warming seas. Journal of Applied Ecology, 45: 1029–1039.

EC. 2019. Regulation (EU) 2019/1241 of the European Parliament and of the Council of 20 June 2019 on the conservation of fisheries resources and the protection of marine ecosystems through technical measures, amending Council Regulations (EC) No 1967/2006, (EC) No 1224/2009 and Regulations (EU) No 1380/2013, (EU) 2016/1139, (EU) 2018/973, (EU) 2019/472 and (EU) 2019/1022 of the European Parliament and of the Council, and repealing Council Regulations (EC) No 894/97, (EC) No 850/98, (EC) No 2549/2000, (EC) No 254/2002, (EC) No 812/2004 and (EC) No 2187/2005

Engelhard, G. H., Pinnegar, J. K., Kell, L. T., and Rijnsdorp, A. D. 2011b. Nine decades of North Sea sole and plaice distribution. ICES Journal of Marine Science, 68: 1090–1104.

Engelhard, G. H., Ellis, J. R., Payne, M., ter Hofstede, R., and Pinnegar, J. K. 2011b. Are ecotypes a meaningful and useful concept for exploring responses to climate change in fish assemblages? ICES Journal of Marine Science, 68: 580–591.

Engelhard, G. H., Peck, M. A., Rindorf, A., Smout, S. C., Deurs, M. Van, Raab, K., Andersen, K. H., et al. 2014. Forage fish, their fisheries, and their predators: who drives whom? ICES Journal of Marine Science, 71: 90–104.

Engelhard, G. H., Peck, M. A., Rindorf, A., Smout, S. C., Deurs, M. Van, Raab, K., Andersen, K. H., et al. 2014b. Forage fish, their fisheries, and their predators: who drives whom? ICES Journal of Marine Science, 71: 90–104.

Engelhard, G. H., Lynam, C. P., García-Carreras, B., Dolder, P. J., and Mackinson, S. 2015. Effort reduction and the large fish indicator: spatial trends reveal positive impacts of recent European fleet reduction schemes. Environmental Conservation, 42: 227–236.

EC 2013. Regulation (EU) No 1380/2013 of the European Parliament and of the Council of 11 December 2013 on the Common Fisheries Policy, amending Council Regulations (EC) No 1954/2003 and (EC) No 1224/2009 and repealing Council Regulations (EC) No 2371/2002 and (EC) No 639/2004 and Council Decision 2004/585/EC

FAO. 2016. Abandoned, lost and discarded gillnets and trammel nets - Methods to estimate ghost fishing mortality, and the status of regional monitoring and management. FAO Fisheries and Aquaculture Technical Paper 600. 79 pp.

Fincham, J. I., Rijnsdorp, A. D., and Engelhard, G. H. 2013. Shifts in the timing of spawning in sole linked to warming sea temperatures. Journal of Sea Research, 75: 69–76.

Gilman, E. 2015. Status of international monitoring and management of abandoned, lost and discarded fishing gear and ghost fishing. Marine Policy, 60: 225–239.

Glorius, S., Craeymeersch, J., van der Hammen, T., Rippen, A., Cuperus, J., van der Weide, B., Steenbergen, J., et al. 2015. Effecten van garnalenvisserij in Natura 2000 gebieden. Rapport C013/15. IMARES Wageningen UR. 162 pp.

Guillen, J., Holmes, S. J., Carvalho, N., Casey, J., Dörner, H., Gibin, M., Mannini, A., et al. 2018. A review of the European union landing obligation focusing on its implications for fisheries and the environment. Sustainabilty, 10: 900.

Haasnoot, T., Kraan, M., and Bush, S. R. 2016. Fishing gear transitions: Lessons from the Dutch flatfish pulse trawl. ICES Journal of Marine Science, 73: 1235–1243.

Hamon, K., and Hintzen, N. 2016. Brexit: Results. Presentation.

Harte, M., Tiller, R., Kailis, G., Burden, M., and Pendleton, L. 2019. Countering a climate of instability: The future of relative stability under the Common Fisheries Policy. ICES Journal of Marine Science, 76: 1951–1958.

Heath, M. R. 2005. Changes in the structure and function of the North Sea fish foodweb, 1973-2000, and the impacts of fishing and climate. ICES Journal of Marine Science, 62: 847–868.

Hiddink, J. G., and ter Hofstede, R. 2008. Climate induced increases in species richness of marine fishes. Global Change Biology, 14: 453–460.

Höffle, H., Van Damme, C. J. G., Fox, C., Lelièvre, S., Loots, C., Nash, R. D. M., Vaz, S., et al. 2018. Linking spawning ground extent to environmental factors — patterns and dispersal during the egg phase of four north sea fishes. Canadian Journal of Fisheries and Aquatic Sciences, 75: 357–374.

Holsman, K. K., Hazen, E. L., Haynie, A., Gourguet, S., Hollowed, A., Bograd, S. J., Samhouri, J. F., et al. 2019. Towards climate resiliency in fisheries management. ICES Journal of Marine Science, 76: 1368–1378.

Hufnagl, M., Peck, M. A., Nash, R. D. M., Pohlmann, T., and Rijnsdorp, A. D. 2013. Changes in potential North Sea spawning grounds of plaice (*Pleuronectes platessa* L.) based on early life stage connectivity to nursery habitats. Journal of Sea Research, 84: 26–39.

ICES Ecosystem Overview. 2018 Greater North Sea Ecoregion – Ecosystem overview: 1–23.

ICES. 2020. Road map for ICES bycatch advice on protected, endangered, and threatened species. In Report of the ICES Advisory Committee, 2020. ICES Advice 2020, section 1.6.

ICES Stock Annex herring. 2018. Stock Annex: Herring (*Clupea harengus*) in Subarea 4 and divisions 3.a and 7.d, autumn spawners (North Sea, Skagerrak and Katte- gat, eastern English Channel). 62 pp.

ICES WGCRAN. 2018. Report of the Working Group on Crangon Fisheries and Life History (WGCRAN).

ICES CM 2018/EPDSG:06. 68 pp.

ICES WGECO. 2020. Working Group on the Ecosystem Effects of Fishing Activities (WGECO). ICES Scientific Reports. 2:26. 43 pp.

ICES WGELECTRA. 2020. ICES Working Group on Electrical Trawling (WGELECTRA). ICES Scientific Reports. 2:37. 108 pp.

ICES WGSAM. 2018. Report of the Working Group on Multispecies Assessment Methods (WGSAM).

ICES CM 2018/HAPISG:20. 99 pp.

ICES WGWIDE. 2019. Working Group on Widely Distributed Stocks (WGWIDE). ICES Scientific Reports. 1:36. 948 pp.

ICES. 2013. Report of the Workshop on the Necessity for Crangon and Cephalopod Management (WKCCM). ICES CM 2013/ACOM:82. 76 pp.

ICES WKFISHDISH. 2016. Report of the Working Group on Fish Distribution Shifts (WKFISHDISH). ICES CM 2016/ ACOM: 55. 197 pp.

ICES WGS2D. 2018. Interim Report of the Working Group on Seasonal to Decadal Prediction of Marine Ecosystems (WGS2D). ICES CM 2018/EPDSG:22. 42 pp.

ICES WKPELA. 2018. Report of the Benchmark Workshop on Pelagic Stocks (WKPELA). ICES CM 2018/ACOM:32. 42 pp.

Jansen, T., and Gislason, H. 2011. Temperature affects the timing of spawning and migration of North Sea mackerel. Continental Shelf Research, 31: 64–72.

Jansen, H. M., Van Den Burg, S., Bolman, B., Jak, R. G., Kamermans, P., Poelman, M., and Stuiver, M. 2016. The feasibility of offshore aquaculture and its potential for multi-use in the North Sea. Aquaculture International, 24: 735–756.

Jansen, T., Post, S., Kristiansen, T., Óskarsson, G. J., Mackenzie, B. R., Broberg, M., and Siegstad, H. 2016b. Ocean warming expands habitat of a rich natural resource and benefits a national economy. Ecological, 26: 2021–2032.

Johnson, M. P., Lordan, C., and Power, A. M. 2013. Habitat and Ecology of *Nephrops norvegicus*. Advances in Marine Biology, 64: 27–63

Kaiser, M. J., Bullimore, B., Newman, P., Lock, K., Gilbert, S., Kaiser, M. J., Bullimore, B., et al. 1996. Catches in ‘ghost fishing’ set nets. Marine Ecology Progress Series, 145: 11–16.

Kaiser, M.J., Clarke, K.R., Hinz, H., Austen, M.C.V., Somerfield, P.J., and Karakassis, I. 2006. Global analysisof response and recovery of benthic biota to fishing. Marine Ecology Progress Series, 311: 1-14.

Karp, M. A., Peterson, J. O., Lynch, P. D., Griffis, R. B., Adams, C. F., Arnold, W. S., Barnett, L. A. K., et al. 2019. Accounting for shifting distributions and changing productivity in the development of scientific advice for fishery management. ICES Journal of Marine Science, 76: 1305–1315.

Lindeboom, H.J., and de Groot, S.J. (eds.). 1998. Impact-II. The effects of different types of fisheries on the North Sea and Irish Sea benthic ecosystems. NIOZ-Rapport 1998-I, RIVO-DLO Report C003/98. 412 pp.

Lindeboom, H. J., Kouwenhoven, H. J., Bergman, M. J. N., Bouma, S., Brasseur, S., Daan, R., Fijn, R. C., et al. 2011. Short-term ecological effects of an offshore wind farm in the Dutch coastal zone; Acompilation. Environmental Research Letters, 6: 035101.

Lindeboom, H., Degraer, S., Dannheim, J., Gill, A. B., and Wilhelmsson, D. 2015. Offshore wind park monitoring programmes, lessons learned and recommendations for the future. Hydrobiologia, 756: 169–180.

Lindegren, M., and Brander, K. 2018. Adapting Fisheries and Their Management To Climate Change: A Review of Concepts, Tools, Frameworks, and Current Progress Toward Implementation. Reviews in Fisheries Science and Aquaculture, 26: 400–415.

Lynam, C. P., Llope, M., Möllmann, C., Helaouët, P., Bayliss-Brown, G. A., and Stenseth, N. C. 2017. Interaction between top-down and bottom-up control in marine food webs. Proceedings of the National Academy of Sciences of the United States of America, 114: 1952–1957.

Madin, E. M. P., Ban, N. C., Doubleday, A., Holmes, T. H., Pecl, G. T., and Smith, F. 2012. Socio-economic and management implications of range-shifting species in marine systems. Global Environmental Change, 22: 137–146.

Marzloff, M. P., Melbourne-Thomas, J., Hamon, K. G., Hoshino, E., Jennings, S., van Putten, I. E., and Pecl, G. T. 2016. Modelling marine community responses to climate-driven species redistribution to guide monitoring and adaptive ecosystem-based management. Global change biology, 22: 2462–2474.

Methratta, E. T., and Dardick, W. R. 2019. Meta-Analysis of Finfish Abundance at Offshore Wind Farms. Reviews in Fisheries Science and Aquaculture, 27: 242–260.

Molenaar, P., and Schram,E. 2018. Increasing the survival of discards in North Sea pulse trawl fisheries. Wageningen, Wageningen Marine Research (University & Research centre), Wageningen Marine Research report C038/18. 39 pp.

Molenaar, P., Steenbergen, J., Glorius, S., and Dammers, M. 2016. Vermindering discards door netinnovatie in de Noorse kreeft visserij. Wageningen, IMARES Wageningen UR (University & Research centre), IMARES Research report C027/16. 119 pp.

Molenaar, P., Soetaert, M., Glorius, S., and Van Opstal, M. 2019. Netinnovatie Kottervisserij II. Wageningen, Wageningen Marine Research (University & Research centre), Wageningen Marine Research report C051/19. 160 pp.

Myers, R. A. 1998. When do environment-recruitment correlations work? Reviews in Fish Biology and Fisheries, 8: 285–305.

Pastoors, M., Van Helmond, E., Van Marlen, B., Van Overzee, H., and De Graaf, E. 2014. Pelagic pilot project discard ban, 2013-2014. Wageningen, IMARES Wageningen UR (University & Research centre), IMARES Research report C071/14. 47 pp.

Pawson, M.G. 2003. The catching capacity of lost static fishing gears: introduction. Fisheries Research, 64: 101-105

Payne, M. R., Hatfield, E. M. C., Dickey-Collas, M., Falkenhaug, T., Gallego, A., Gr??ger, J., Licandro, P., et al. 2009. Recruitment in a changing environment: The 2000s North Sea herring recruitment failure. ICES Journal of Marine Science, 66: 272–277.

Pinsky, M. L., and Fogarty, M. 2012. Lagged social-ecological responses to climate and range shifts in fisheries. Climatic Change, 115: 883–891.

Pinsky, M. L., Reygondeau, G., Caddell, R., Palacios-Abrantes, J., Spijkers, J., and Cheung, W. W. L. 2018. Preparing ocean governance for species on the move. Science, 360: 1189–1191.

RCG. 2019. Regional Coordination Group North Atlantic and North Sea & Eastern Artic. 114 pp. ( https://datacollection.jrc.ec.europa.eu/docs/rcg)

Reid, P. C., Battle, E. J. V., Batten, S. D., and Brander, K. M. 2000. Impacts of fisheries on plankton community structure. ICES Journal of Marine Science, 57: 495–502.

Richardson, K., Hardesty, B. D., and Wilcox, C. 2019. Estimates of fishing gear loss rates at a global scale: A literature review and meta‐analysis. Fish and Fisheries, 20: 1218–1231.

Rijnsdorp, A. D., Bastardie, F., Bolam, S. G., Buhl-Mortensen, L., Eigaard, O. R., Hamon, K. G., Hiddink, J. G., et al. 2016. Towards a framework for the quantitative assessment of trawling impact on the seabed and benthic ecosystem. ICES Journal of Marine Science, 73: i127–i138.

Rijnsdorp, A. D., Peck, M. A., Engelhard, G. H., Möllmann, C., and Pinnegar, J. K. 2009. Resolving the effect of climate change on fish populations. ICES Journal of Marine Science, 66: 1570–1583.

Rutterford, L. A., Simpson, S. D., Jennings, S., Johnson, M. P., Blanchard, J. L., Schön, P.-J., Sims, D. W., et al. 2015. Future fish distributions constrained by depth in warming seas. Nature Climate Change, 5: 569–573.

Schmidt, J. O., Van Damme, C. J. G., Röckmann, C., and Dickey-Collas, M. 2009. Recolonisation of spawning grounds in a recovering fish stock: recent changes in North Sea herring. Scientia Marina, 73: 153–157.

Shin, Y.-J., Houle, J. E., Akoglu, E., Blanchard, J. L., Bundy, A., Coll, M., Demarcq, H., et al. 2018. The specificity of marine ecological indicators to fishing in the face of environmental change: A multi-model evaluation. Ecological Indicators, 89: 317–326.

Sissener, E. H., and Bjørndal, T. 2005. Climate change and the migratory pattern for Norwegian spring-spawning herring - Implications for management. Marine Policy, 29: 299–309.

Skern-Mauritzen, M., Ottersen, G., Handegard, N. O., Huse, G., Dingsør, G. E., Stenseth, N. C., and Kjesbu, O. S. 2016. Ecosystem processes are rarely included in tactical fisheries management. Metroeconomica, 67: 165–175.

Slijkerman, D.M.E., Dammers, M., Molenaar, P., Van der Hammen, T., Van Hoppe, M. 2016. Vermindering Discards Garnalenvisserij door Netaanpassingen (VDGN); Effectiviteit brievenbus en maaswijdte. Wageningen, IMARES Wageningen UR (University & Research centre), IMARES rapport C169/15. 74 pp.

Steenbergen, J., Ulleweit, J., Machiels, M., Nijman, R., Panten, K., and Van Helmond, E. 2015. Discards Sampling of the Dutch and German Brown Shrimp Fisheries in 2009 - 2012. Stichting DLO, Centre for Fisheries Research (CVO), CVO report 15.003. 40pp.

Steenbergen, J., Van Kooten, T., Van de Wolfshaar, K., Trapman, B., and Van der Reijden, K. 2015. Management options for brown shrimp (*Crangon crangon*) fisheries in the North Sea. Wageningen, IMARES Wageningen UR (University & Research centre), IMARES report C181/15. 63 pp.

Stelfox, M., Hudgins, J., and Sweet, M. 2016. A review of ghost gear entanglement amongst marine mammals, reptiles and elasmobranchs. Marine Pollution Bulletin, 111: 6–17.

Stenberg, C., Støttrup, J. G., Van Deurs, M., Berg, C. W., Dinesen, G. E., Mosegaard, H., Grome, T. M., et al. 2015. Long-term effects of an offshore wind farm in the North Sea on fish communities. Marine Ecology Progress Series, 528: 257–265.

Teal, L. R., van Hal, R., van Kooten, T., Ruardij, P., and Rijnsdorp, A. D. 2012. Bio-energetics underpins the spatial response of North Sea plaice (*Pleuronectes platessa* L.) and sole (*Solea solea* L.) to climate change. Global Change Biology, 18: 3291–3305.

Temming, A., and Hufnagl, M. 2015. Decreasing predation levels and increasing landings challenge the paradigm of non-management of North Sea brown shrimp (*Crangon crangon*). ICES Journal of Marine Science, 72: 804–823.

ter Hofstede, R., Hiddink, J. G., and Rijnsdorp, A. D. 2010. Regional warming changes fish species richness in the eastern North Atlantic Ocean. Marine Ecology Progress Series, 414: 1–9.

Tonk, L., and Rozemeijer, M.J.C. 2019. Ecology of the brown crab (*Cancer pagurus*) and production potential for passive fisheries in Dutch offshore wind farms. Wageningen, Wageningen Marine Research (University & Research centre), Wageningen Marine Research report number C064/19A, 49 pp.

Trenkel, V.M., Huse, G., MacKenzie, B.R., Alvarez, P., Arrizabalaga, H., Castonguay, M., Goñi, N., et al. 2014. Comparative ecology of widely distributed pelagic fish species in the North Atlantic: Implications for modelling climate and fisheries impacts. Progress in Oceanography, 129: 219-243.

Turenhout, M., Hamon, K., Hintzen, N., and Poppe, K. 2017. Brexit and the Dutch fishing industry. EuroChoices, 16(2): 24-25.

Ulleweit, J., Van Overzee, H., Van Helmond, E., and Panten, K. 2016. Discard sampling of the Dutch and German pelagic freezer fishery operating in European waters in 2013-2014 - Joint Report of the Dutch and German national sampling programmes. Stichting DLO, Centre for Fisheries Research (CVO), CVO report 15.014. 62pp.

Van der Reijden, K.J., Verkempycnk, R., Nijman, R.R., Uhlmann, S.S., Van Helmond, A.T.M., and Coers, A., 2014. Discard self-sampling of Dutch bottom-trawl and seine fisheries in 2013. Stichting DLO, Centre for Fisheries Research (CVO), CVO report 14.007. 74pp.

Van Der Veer, H. W., Feller, R. J., Weber, A., and Ij. Witte, J. 1998. Importance of predation by crustaceans upon bivalve spat in the intertidal zone of the Dutch Wadden Sea as revealed by immunological assays of gut contents. Journal of Experimental Marine Biology and Ecology, 231: 139–157.

Van Gemert, R., and Andersen, K. H. 2018. Challenges to fisheries advice and management due to stock recovery. ICES Journal of Marine Science, 75: 1864–1870.

van Hal, R., Griffioen, A. B., and van Keeken, O. A. 2017. Changes in fish communities on a small spatial scale, an effect of increased habitat complexity by an offshore wind farm. Marine Environmental Research, 126: 26–36.

Van Marlen, B., Van Overzee, H., Van Helmond, E., Tamis, J., De Vries, P., Dammers, M., and Cuperus, J. 2015. VIP - Pelagic trawl innovation. Wageningen, IMARES Wageningen UR (University & Research centre), IMARES rapport C109/15. 33 pp.

Van Marlen, B., Molenaar, P., Bol, R., Dammers, M., Groeneveld, K., Machiels, M.A.M., and Den Heijer, W.M. 2016. Netinnovatie Kottervisserij. Wageningen, IMARES Wageningen UR (University & Research centre), IMARES rapport C110/15. 132 pp.

Van Marlen, B., Molengaar P., Dammers, M., and Van Hoppe, M. 2015. Selectieve twinrig op platvis. Wageningen, IMARES Wageningen UR (University & Research centre), IMARES rapport C179/15. 66 pp.

Van Overzee, H., Van Helmond, E., and Ulleweit, J. 2017. Catch sampling of the pelagic freezer trawler fishery operating in European waters in 2015-2016 Joint report of the Dutch and German national sampling programmes. Stichting DLO, Centre for Fisheries Research (CVO), CVO report 17.021. 55pp.

Van Overzee, H., Dammers, M., and Bleeker, K. 2019. Discard self-sampling of Dutch bottom-trawl fisheries in 2017-2018. Stichting DLO, Centre for Fisheries Research (CVO), CVO report 19.024. 56pp.

Van Overzee, H.M.J., Ulleweit, J., Van Helmond, A.T.M., and Bangma, T. 2020. Catch sampling of the pelagic freezer trawler fishery operating in European waters in 2017-2018 Joint report of the Dutch and German national sampling programmes. Stichting DLO, Centre for Fisheries Research (CVO), CVO report 20.004. 53pp.

Van Rijn, J., and Molenaar P. 2019. Selectiviteitsoptimalisatie van de pulsvisserij. Wageningen Marine Research, Wageningen Marine Research rapport C072/19, 42 pp.

Van Rijn, J., Van Helmond, A.T.M., and Molenaar, P. 2017. Pelagic blue whiting trawl innovation: hake grid. Wageningen, Wageningen Marine Research (University & Research centre), Wageningen Marine Research report number C080/17, 19 pp.

Verkempynck, R., Van Overzee, H., and Dammers, M. 2018. Discard self-sampling of Dutch bottom-trawl fisheries in 2014-2016. Stichting DLO, Centre for Fisheries Research (CVO), CVO report 18.007. 102pp.

Verschueren, B., Lenoir, H., Soetaert, M., and Polet, H. 2019. Revealing the by-catch reducing potential of pulse trawls in the brown shrimp (*Crangon crangon*) fishery. Fisheries Research, 211: 191–203.

**IPIMAR**

Alzorriz, N. Jardim, E., Poos ,J.J. (2018) Likely status and changes in the main economic and fishery indicators under the landing obligation: A case study of the Basque trawl fishery. Fisheries Research 205, 86–95

Azevedo, M. Castro, J. Fernandes, A. C., Marín, M., and Prista, N. (2010). Identification of fishing units with discarding level needed to be reduced. FAROS Project, Deliverable 1.1: 61 p.

B.I. deVos, R.Döring , M.Aranda , F.C.Buisman , K.Frangoudes , L.Goti , C.Macher , C.D. Maravelias , A.Murillas-Maza, O.vanderValk , P.Vasilakopoulos (2016) New modes of fisheries governance: Implementation of the landing obligation in four European countries. Marine Policy 64, 1–8

Baeta, F. Ana Pinheiro, Madalena Corte-Real, Jose Lino Costa, Pedro Raposo de Almeida, Henrique Cabral, Maria Jose Costa (2005). Are the fisheries in the Tagus estuary sustainable? Fisheries Research 76 (2005) 243–251

Baeta, F., Marisa Batista, Anabela Maia, Maria José Costa, Henrique Cabral (2010). Elasmobranch bycatch in a trammel net fishery in the Portuguese west coast. Fisheries Research 102.123–129

Baeta, F., Maria José Costa, Henrique Cabral (2009) Trammel nets’ ghost fishing off the Portuguese central coast. Fisheries Research Volume 98, Issues 1–3, 33-39

Batista, M.I., Célia M. Teixeira, Henrique N. Cabral (2009). Catches of target species and bycatches of an artisanal fishery: The case study of a trammel net fishery in the Portuguese coast. Fisheries Research 100 (2009) 167-177

Bordalo-Machado,P., Ana Cláudia Fernandes, Ivone Figueiredo, Olga Moura, Sara Reis, Graça Pestana and Leonel Serrano Gordo (2009).The black scabbardfish (*Aphanopus carbo* Lowe, 1839) fisheries from the Portuguese mainland and Madeira Island. Scientia Marina 73S2

Borges, M.F.; Mendes, Hugo; Santos, A.M. (2004). The Multi-scale impact of theNAO index on fish recruitment variability in the upwelling system off Portugal *in* Proceedings The Influence of Climate Change on North Atlantic Fish Stocks,Bergen. Global Ocean Ecosystem Dynamics.: The Influence of Climate Changeon North Atlantic Fish Stocks, Bergen. Global Ocean Ecosystem Dynamics.

Borges, T.C, K. Erzini, L. Bentes, M. E. Costa, J. M. S. GoncË alves, P. G. Lino, C. Pais and J. Ribeiro(2001). By-catch and discarding practices in five Algarve (southern Portugal) métiers. J. Appl. Ichthyol. 17 (2001), 104-114

Campos, A., Fonseca,P.(2003) The use of separator panels and square mesh windows forby-catch reduction in the crustacean trawl fishery off the Algarve (South Portugal) Fisheries Research 69, 147–156

Campos, C., Paulo Fonseca, Victor Henriques (2003) Size selectivity for four fish species of the deep groundfish assemblage off the Portuguese southwest coast: evidence of mesh size, mesh configuration and cod end catch effects Fisheries Research 63. 213–233

Cardoso, I., Moura, T., Mendes, H., Azevedo, M., Silva, C., Murta, A. (2015). An ecosystem approach to Portuguese mixed fisheries. ICES Journal of Marine Science, 72(9): 2618-2626.

Catchpole, T.L, Ana Ribeiro-Santos, Stephen C. Mangi, Christopher Hedley, Tim S. Gray (2017). The challenges of the landing obligation in EU fisheries. Marine Policy 82, 76–86

Coelho, R., Erzini, K., (2008). Effects of fishing methods on deep water shark species caught as by-catch off southern Portugal. Hydrobiologia 606,187-193.

EcoFishMan (2013) " Ecosystem-based Responsive Fisheries Management in Europe " Grant agreement No: FP7-265401. Deliverable WP5.3

Fernandes, A.C. NélidaPérez NunoPrista JuanSantos, ManuelaAzevedo (2015). Discards composition from Iberian trawl fleets. Marine Policy53 (2015) 33–44

Fonseca, P., Campos, A., Mendes, B. and Larsen, R.B., (2005b). Potential use of a Nordmøre grid for by‐catch reduction in a Portuguese bottom‐trawl multispecies fishery. *Fisheries Research* 73, 49‐66

Fonseca,P., Aida CamposBeatriz MendesRoger B. Larsen (2005a). Potential use of a Nordmøre grid for by-catch reduction in a Portuguese bottom-trawl multispecies fishery. Fisheries Research 73 (2005) 49–66

Garrido, S., Silva, A., Marques, V., Figueiredo, I., Bryère, P., Mangin, A., & Santos, A. M. P. (2017). Temperature and food-mediated variability of European Atlantic sardine recruitment. Progress in Oceanography, 159, 267-275.

Garrido, S., Van der Lingen, C. D. (2014). Feeding Biology and Ecology. In: Konstantinos, G. (Ed.), Biology and Ecology of Sardines and Anchovies, CRC Press, pp. 122-189.

Gordo, L. (2009). Black scabbardfish (Aphanopus carbo Lowe, 1839) in the southern Northeast Atlantic: considerations on its fishery. Scientia Marina 73S2

ICES. (2008). Report of the Working group for regional ecosystem description (WGRED). ICES Advisory Committee. ICES CM 2008/ACOM: 47.

ICES. (2019a). Bay of Biscay and Iberian Waters Ecoregion – Fisheries overview data. https://doi.org/10.17895/ices.data.5697

ICES. 2018. Report of the Working Group on the Biology and Assessment of Deep-sea Fisheries Resources (WGDEEP), 11–18 April, ICES HQ, Copenhagen, Denmark. ICES CM 2018/ACOM:14. 771 pp.

ICES. 2019. Working Group on Bycatch of Protected Species (WGBYC). ICES Scientific Reports. 1:51. 163pp.http://doi.org/10.17895/ices.pub.5563

IN-EX-FISH (2008). Deliverable WP 5 Case Study – West Iberian Sea

Karim Erzini, Jorge M. S. Gonçalves, Luis Bentes, Pedro G. Lino, and João Cruz (1996). Species and size selectivity in a Portuguese multispecies artisanal long-line fishery. ICES Journal of Marine Science, 53: 811–819.

Leitão, F. Ravi R. MaharajVasco M.N.C.S. VieiraAlexandra TeodósioWilliam W.L. Cheung. (2018) The effect of regional sea surface temperature rise on fisheries along the Portuguese Iberian Atlantic coast Aquatic Conservation Marine and Freshwater Ecosystems

Malta et al. 2016 https://doi.org/10.1016/j.fishres.2016.02.009

Marçalo 2009, SARDINE (Sardina pilchardus) DELAYED MORTALITY ASSOCIATED WITH PURSE SEINE SLIPPING:CONTRIBUTING STRESSORS AND RESPONSES, PhD Thesis

Marçalo et al. 2006 DOI 10.1007/s00227-006-0277-5

Marçalo et al. 2008 doi:10.1111/j.1095-8649.2007.01660.x

Marçalo et al. 2010 doi:10.1093/icesjms/fsp244

Marçalo et al. 2013 doi:10.1111/jfb.12184

Marçalo et al. 2015 doi:10.1093/icesjms/fsv076

Marçalo et al. 2018 https://doi.org/10.1371/journal.pone.0195433

Marçalo et al. 2018 https://doi.org/10.1007/s00227-018-3285-3

Marçalo et al. 2019 https://doi.org/10.1007/978-3-030-03308-8\_15

Mendes, H., Murta,A., Vilela Mendes, R. (2015). Long range dependence and the dynamics of exploited fish populations. Advances in Complex Systems Vol. 18, Nos. 7/8.

Mendes, Hugo; Borges, M.F.; Scott, C.; Frid, C. (2008). "Climatic impact on hake recruitment and implications for fisheries management". In Proceedings of the ICES Annual Science Conference 2008: ICES Annual Science Conference 2008.

Morato, T. (2012). Description of environmental issues, fish stocks and fisheries in the EEZs around the Azores and Madeira.

Oliveira et al. 2015 10.1016/j.gecco.2014.11.006

Payne et al 2017 https://www.frontiersin.org/articles/10.3389/fmars.2017.00289/full

Pereira et al. 2018 10.1016/j.ocecoaman.2017.12.014

Pérez, N., Prista, N., Santos, J., Fernandes, A.C., Azevedo, M., Ordoñez, T., Bellido J., and Fernández J. (2010). Manual on the strategies and solutions on board to reduce discards. FAROS Project, Deliverable 1.2: 122 p

Santos, A. M. P., Borges, M.F., Groom, S. (2001). Sardine and horse mackerel recruitment and upwelling off Portugal. ICES Journal of Marine Science. Vol .58, No 3, 589-596 doi:10.1006/jmsc.2001.106.

Silva et al 2018 https://doi.org/10.1016/j.dsr2.2018.10.010

Silva, C., Mendes, H., Rangel, M., Wise, L.,Erzini, K., Borges, F., Campos, A.,Viðarsson, J., Nielsen,K. (2014). Development of a Responsive Fisheries Management System for the Portuguese crustacean bottom trawl fishery. Marine Policy, 52: 19-25.

Solari, A. P., Santamaría, M. T. G., Borges, M. F., Santos, A. M. P., Mendes, H., Balguerías, E., Dıaz Cordero, J. A., Castro, J. J., Bas, C. (2010). On the dynamics of *Sardina pilchardus*: orbits of stability and environmental forcing. – ICES Journal of Marine Science, 67: 1565–1573.https://doi.org/10.1093/icesjms/fsq107.

Suazo et al. 2017 10.1016/j.ocecoaman.2017.12.014

Szalaj et al. 2018 10.1093/icesjms/fsy094

Teixeira CM, Gamito R, Leitão F, Murta A, Cabra HN, Erzini K, Costa MJ. (2016). Environmental infuence on commercial Fshery landings of small pelagic Fish in Portugal. Reg. Environ. Change 16: 709–716.https://doi.org/10.1007/s10113-015-0786-1.

Veiga-Malta et al. 2019 https://doi.org/10.3354/meps12724

Veiga-Malta, T., Szalaj, D., Angélico, M.M., Azevedo, M., Farias, I., Garrido, S., Lourenço, S., Marçalo, A., Marques, V., Moreno A., Oliveira, P.B., Paiva, V.H., Prista, N., Silva, C., Sobrinho-Gonçalves, L., Vingada, J., A. Silva (2019 ). First representation of the trophic structure and functioning of the Portuguese continental shelf ecosystem: insights on the role of sardine, Marine Ecology Progress Series, DOI: 10.3354/meps12724.

Wise et al 2019 https://doi.org/10.3354/meps12656

Wise, L., Fonseca, P., Murta, A., Silva, C., Mendes, H., Carvalho, J.P., Borges, F., Campos, A. (2015). A knowledge-based model for evaluating the impact of gear-based management measures under Europe’s new Common Fisheries Policy. ICES Journal of Marine Science 72,4

Annexe 2. EAFM Review: Search Protocols

**Overview**

Objective: We should catalogue ecosystem challenges arising from/faced by the fishing. Therefore, we explore the links ‘fisheries’ -> ‘Ecosystem’, ‘Ecosystem’ -> ‘fishing opportunities’, and ‘Social and regulation framing’ -> ‘fisheries’. We are not examining the ‘fisheries’ -> ‘socioeconomics or regulation framing’ because the effect is expected quite limited, neither ‘Other activities (than fishing)’ -> ‘Ecosystem’ because too broad or unspecific.

Every search should be undertaken in all databases agreed upon. Every search should be added to this list and given a reference number. The full list of papers should be exported as .RIS file extension or similar and saved to the project online. The file name should reflect for which review it was taken and the general structure of the search.

All raw search results will be uploaded to the spreadsheet software for duplicate removal and screening.

**Review 1. Fisheries Effects on Ecosystem Components**

*Objective*

Review fisheries impacts on ecosystem structure and functioning. This includes the effect of fisheries on ecosystem components such a non-commercially exploited ecosystem components, i.e. bycatch of sensitive or protected species (e.g. marine mammals), or the physical disturbance of biodiversity hotspots such as vulnerable habitats (VMEs). For example, the wording ‘viable habitat of fish stocks are being impacted by degrading fishing techniques’ defines an ecosystem challenge, where the targeted status is ‘viable’, the ecosystem component is ‘habitat of fish stocks’ and the impacting agent is ‘degrading fishing techniques’. The primary question framing the determinants of the literature search might be ‘how, at what scale, to what intensity is the habitat affected by the fishing?’. For example, a search query here might look like (“Fisheries” OR “Fishing” OR “physical abrasion” OR “trawl”, etc.) AND (“seafloor” OR “benthos” OR “habitat” OR “nurseries”, etc.) AND (“softbottom macrofauna” OR “abundance” OR “density”, etc.) combining pressures on the fisheries resources, ecosystem component states, and indicators.

*Challenges*

An ecosystem challenge here defines as *a* change in the pressure resulting from the fishing activities, that is significant enough to affect the ecosystem components severely or beyond a pre-defined threshold. The management measures should take up these challenges by implementing actions that would negate or minimise the impacts.

*General Structure*

[Ecosystem component] AND [Activity] AND [Pressure] AND [Impact]

*Explanation*

“Ecosystem component” is a list of search terms linked by “OR” that changes for each new search. “Activity” and “Pressure” are lists of search terms linked by “OR” that are not changing across searches.

*Scopus-specific query syntax*

TITLE-ABS-KEY(

(

"benthic\* habitat\*" OR "benthos" OR "seafloor" OR "seabed" OR "macrofaunal"

)

AND NOT "freshwater\*" AND NOT "aquaculture\*" AND NOT "paleo\*"

)

AND

TITLE-ABS-KEY(

(effect\* PRE/3 "benthic\* habitat\*") OR (impact\* PRE/3 "benthic\* habitat\*") OR(challeng\* PRE/3 "benthic\* habitat\*") OR(influenc\* PRE/3 "benthic\* habitat\*") OR(affect\* PRE/3 "benthic\* habitat\*") OR(chang\* PRE/3 "benthic\* habitat\*")

OR (effect\* PRE/3 benthos) OR (impact\* PRE/3 benthos) OR(challeng\* PRE/3 benthos) OR(influenc\* PRE/3 benthos) OR(affect\* PRE/3 benthos) OR(chang\* PRE/3 benthos)

OR (effect\* PRE/3 seafloor) OR (impact\* PRE/3 seafloor) OR(challeng\* PRE/3 seafloor) OR(influenc\* PRE/3 seafloor) OR(affect\* PRE/3 seafloor) OR(chang\* PRE/3 seafloor)

OR (effect\* PRE/3 seabed) OR (impact\* PRE/3 seabed) OR(challeng\* PRE/3 seabed) OR(influenc\* PRE/3 seabed) OR(affect\* PRE/3 seabed) OR(chang\* PRE/3 seafloor)

OR (effect\* PRE/3 macrofaunal) OR (impact\* PRE/3 macrofaunal) OR(challeng\* PRE/3 macrofaunal) OR(influenc\* PRE/3 macrofaunal) OR(affect\* PRE/3 seabed) OR(chang\* PRE/3 macrofaunal)

OR ("benthic\* habitat\*" PRE/3 "impacted by") OR ("benthic\* habitat\*" PRE/3 "challenged by") OR ("benthic\* habitat\*" PRE/3 "influenced by") OR ("benthic\* habitat\*" PRE/3 "affected by") OR ("benthic\* habitat\*" PRE/3 "changed by")

OR ("benthos" PRE/3 "impacted by") OR ("benthos" PRE/3 "challenged by") OR ("benthos" PRE/3 "influenced by") OR ("benthos" PRE/3 "affected by") OR ("benthos" PRE/3 "changed by")

OR ("seafloor" PRE/3 "impacted by") OR ("seafloor" PRE/3 "challenged by") OR ("seafloor" PRE/3 "influenced by") OR ("seafloor" PRE/3 "affected by") OR ("seafloor" PRE/3 "changed by")

OR ("seabed" PRE/3 "impacted by") OR ("seabed" PRE/3 "challenged by") OR ("seabed" PRE/3 "influenced by") OR ("seabed" PRE/3 "affected by") OR ("seabed" PRE/3 "changed by")

OR ("macrofaunal" PRE/3 "impacted by") OR ("macrofaunal" PRE/3 "challenged by") OR ("macrofaunal" PRE/3 "influenced by") OR ("macrofaunal" PRE/3 "affected by") OR ("macrofaunal" PRE/3 "changed by")

)

AND

TITLE-ABS-KEY(

(fishing PRE/3 effect\*) OR (fishing PRE/3 impact\*) OR(fishing PRE/3 challeng\*) OR(fishing PRE/3 influenc\*) OR(fishing PRE/3 affect\*) OR(fishing PRE/3 chang\*)

OR (fisher\* PRE/3 effect\*) OR (fisher\* PRE/3 impact\*) OR(fisher\* PRE/3 challeng\*) OR(fisher\* PRE/3 influenc\*) OR(fisher\* PRE/3 affect\*) OR(fisher\* PRE/3 chang\*)

OR ("impacted by" PRE/3 fishing) OR("challenged by" PRE/3 fishing) OR("influenced by" PRE/3 fishing) OR("affected by" PRE/3 fishing) OR("changed by" PRE/3 fishing)

OR ("impacted by" PRE/3 fisher\*) OR("challenged by" PRE/3 fisher\*) OR("influenced by" PRE/3 fisher\*) OR("affected by" PRE/3 fisher\*) OR("changed by" PRE/3 fisher\*)

)

AND

 TITLE-ABS-KEY (

"North Sea" OR "wadden sea" OR "Baltic" OR "Atlantic Ocean" OR "North-East Atlantic" OR "Kattegat" OR "Skagerrak" OR "European waters" OR "Celtic Sea" OR "Irish Sea" OR "Bay of Biscay" OR "English Channel"

)

AND PUBYEAR AFT 2000

TITLE-ABS-KEY(

(

foodweb\* OR "food web\*" OR "food chain" OR "trophic interaction" OR "functional group\*" OR "trophic level" OR "communit\*" OR "ecosystem\*"

)

AND NOT "freshwater\*" AND NOT "aquaculture\*" AND NOT "paleo\*"

)

AND

TITLE-ABS-KEY(

(effect\* PRE/3 exploit\*) OR (impact\* PRE/3 exploit\*) OR(challeng\* PRE/3 exploit\*) OR(influenc\* PRE/3 exploit\*) OR(affect\* PRE/3 exploit\*) OR(chang\* PRE/3 exploit\*)

OR (effect\* PRE/3 harvest\*) OR (impact\* PRE/3 harvest\*) OR(challeng\* PRE/3 harvest\*) OR(influenc\* PRE/3 harvest\*) OR(affect\* PRE/3 harvest\*) OR(chang\* PRE/3 harvest\*)

OR (effect\* PRE/3 living) OR (impact\* PRE/3 living) OR(challeng\* PRE/3 living) OR(influenc\* PRE/3 living) OR(affect\* PRE/3 living) OR(chang\* PRE/3 living)

OR (exploit\* PRE/3 "impacted by") OR (exploit\* PRE/3 "challenged by") OR (exploit\* PRE/3 "influenced by") OR (exploit\* PRE/3 "affected by") OR (exploit\* PRE/3 "changed by")

OR (harvest\* PRE/3 "impacted by") OR (harvest\* PRE/3 "challenged by") OR (harvest\* PRE/3 "influenced by") OR (harvest\* PRE/3 "affected by") OR (harvest\* PRE/3 "changed by")

OR ("living" PRE/3 "impacted by") OR ("living" PRE/3 "challenged by") OR ("living" PRE/3 "influenced by") OR ("living" PRE/3 "affected by") OR ("living\*" PRE/3 "changed by")

)

AND

TITLE-ABS-KEY(

(fishing PRE/3 effect\*) OR (fishing PRE/3 impact\*) OR(fishing PRE/3 challeng\*) OR(fishing PRE/3 influenc\*) OR(fishing PRE/3 affect\*) OR(fishing PRE/3 chang\*)

OR (fisher\* PRE/3 effect\*) OR (fisher\* PRE/3 impact\*) OR(fisher\* PRE/3 challeng\*) OR(fisher\* PRE/3 influenc\*) OR(fisher\* PRE/3 affect\*) OR(fisher\* PRE/3 chang\*)

OR ("impacted by" PRE/3 fishing) OR("challenged by" PRE/3 fishing) OR("influenced by" PRE/3 fishing) OR("affected by" PRE/3 fishing) OR("changed by" PRE/3 fishing)

OR ("impacted by" PRE/3 fisher\*) OR("challenged by" PRE/3 fisher\*) OR("influenced by" PRE/3 fisher\*) OR("affected by" PRE/3 fisher\*) OR("changed by" PRE/3 fisher\*)

)

AND

 TITLE-ABS-KEY (

"North Sea" OR "wadden sea" OR "Baltic" OR "Atlantic Ocean" OR "North-East Atlantic" OR "Kattegat" OR "Skagerrak" OR "European waters" OR "Celtic Sea" OR "Irish Sea" OR "Bay of Biscay" OR "English Channel"

)

AND PUBYEAR AFT 2000

TITLE-ABS-KEY(

(

fish OR exploit\* OR harvest\* OR "living"

)

AND NOT "freshwater\*" AND NOT "aquaculture\*" AND NOT "paleo\*"

)

AND

TITLE-ABS-KEY(

(effect\* PRE/3 fish) OR (impact\* PRE/3 fish) OR(challeng\* PRE/3 fish) OR(influenc\* PRE/3 fish) OR(affect\* PRE/3 fish) OR(chang\* PRE/3 fish)

OR (effect\* PRE/3 exploit\*) OR (impact\* PRE/3 exploit\*) OR(challeng\* PRE/3 exploit\*) OR(influenc\* PRE/3 exploit\*) OR(affect\* PRE/3 exploit\*) OR(chang\* PRE/3 exploit\*)

OR (effect\* PRE/3 harvest\*) OR (impact\* PRE/3 harvest\*) OR(challeng\* PRE/3 harvest\*) OR(influenc\* PRE/3 harvest\*) OR(affect\* PRE/3 harvest\*) OR(chang\* PRE/3 harvest\*)

OR (effect\* PRE/3 living) OR (impact\* PRE/3 living) OR(challeng\* PRE/3 living) OR(influenc\* PRE/3 living) OR(affect\* PRE/3 living) OR(chang\* PRE/3 living)

OR (exploit\* PRE/3 "impacted by") OR (exploit\* PRE/3 "challenged by") OR (exploit\* PRE/3 "influenced by") OR (exploit\* PRE/3 "affected by") OR (exploit\* PRE/3 "changed by")

OR (harvest\* PRE/3 "impacted by") OR (harvest\* PRE/3 "challenged by") OR (harvest\* PRE/3 "influenced by") OR (harvest\* PRE/3 "affected by") OR (harvest\* PRE/3 "changed by")

OR ("living" PRE/3 "impacted by") OR ("living" PRE/3 "challenged by") OR ("living" PRE/3 "influenced by") OR ("living" PRE/3 "affected by") OR ("living\*" PRE/3 "changed by")

)

AND

TITLE-ABS-KEY(

(fishing PRE/3 effect\*) OR (fishing PRE/3 impact\*) OR(fishing PRE/3 challeng\*) OR(fishing PRE/3 influenc\*) OR(fishing PRE/3 affect\*) OR(fishing PRE/3 chang\*)

OR (fisher\* PRE/3 effect\*) OR (fisher\* PRE/3 impact\*) OR(fisher\* PRE/3 challeng\*) OR(fisher\* PRE/3 influenc\*) OR(fisher\* PRE/3 affect\*) OR(fisher\* PRE/3 chang\*)

OR ("impacted by" PRE/3 fishing) OR("challenged by" PRE/3 fishing) OR("influenced by" PRE/3 fishing) OR("affected by" PRE/3 fishing) OR("changed by" PRE/3 fishing)

OR ("impacted by" PRE/3 fisher\*) OR("challenged by" PRE/3 fisher\*) OR("influenced by" PRE/3 fisher\*) OR("affected by" PRE/3 fisher\*) OR("changed by" PRE/3 fisher\*)

)

AND

 TITLE-ABS-KEY (

"North Sea" OR "wadden sea" OR "Baltic" OR "Atlantic Ocean" OR "North-East Atlantic" OR "Kattegat" OR "Skagerrak" OR "European waters" OR "Celtic Sea" OR "Irish Sea" OR "Bay of Biscay" OR "English Channel"

)

AND PUBYEAR AFT 2000

# Query 4:

TITLE-ABS-KEY(

(

bycatch\* OR "non-target species" OR "marine mammal\*" OR "seabird\*" OR "sea bird\*" OR "by-catch" OR "bycaught" OR "by-caught" OR "incidental catch\*"

)

AND NOT "freshwater\*" AND NOT "aquaculture\*" AND NOT "paleo\*"

)

AND

TITLE-ABS-KEY(

(effect\* PRE/3 by-catch\*) OR (impact\* PRE/3 by-catch\*) OR(challeng\* PRE/3 by-catch\*) OR(influenc\* PRE/3 by-catch\*) OR(affect\* PRE/3 by-catch\*) OR(chang\* PRE/3 by-catch\*)

OR (effect\* PRE/3 bycaught) OR (impact\* PRE/3 bycaught) OR(challeng\* PRE/3 bycaught) OR(influenc\* PRE/3 bycaught) OR(affect\* PRE/3 bycaught) OR(chang\* PRE/3 bycaught)

OR (effect\* PRE/3 by-caught) OR (impact\* PRE/3 by-caught) OR(challeng\* PRE/3 by-caught) OR(influenc\* PRE/3 by-caught) OR(affect\* PRE/3 by-caught) OR(chang\* PRE/3 by-caught)

OR (effect\* PRE/3 bycatch\*) OR (impact\* PRE/3 bycatch\*) OR(challeng\* PRE/3 bycatch\*) OR(influenc\* PRE/3 bycatch\*) OR(affect\* PRE/3 bycatch\*) OR(chang\* PRE/3 bycatch\*)

OR (effect\* PRE/3 "incidental catch\*") OR (impact\* PRE/3 "incidental catch\*") OR(challeng\* PRE/3 "incidental catch\*") OR(influenc\* PRE/3 "incidental catch\*") OR(affect\* PRE/3 "incidental catch\*") OR(chang\* PRE/3 "incidental catch\*")

OR (effect\* PRE/3 "non-target species") OR (impact\* PRE/3 "non-target species") OR(challeng\* PRE/3 "non-target species") OR(influenc\* PRE/3 "non-target species") OR(affect\* PRE/3 "non-target species") OR(chang\* PRE/3 "non-target species")

OR (effect\* PRE/3 "marine mammal\*") OR (impact\* PRE/3 "marine mammal\*") OR(challeng\* PRE/3 "marine mammal\*") OR(influenc\* PRE/3 "marine mammal\*") OR(affect\* PRE/3 "marine mammal\*") OR(chang\* PRE/3 "marine mammal\*")

OR (effect\* PRE/3 "seabird\*") OR (impact\* PRE/3 "seabird\*") OR(challeng\* PRE/3 "seabird\*") OR(influenc\* PRE/3 "seabird\*") OR(affect\* PRE/3 "seabird\*") OR(chang\* PRE/3 "seabird\*")

OR (by-catch\* PRE/3 "impacted by") OR (by-catch\* PRE/3 "challenged by") OR (by-catch\* PRE/3 "influenced by") OR (by-catch\* PRE/3 "affected by") OR (by-catch\* PRE/3 "changed by")

OR ("incidental catch\*" PRE/3 "impacted by") OR ("incidental catch\*" PRE/3 "challenged by") OR ("incidental catch\*" PRE/3 "influenced by") OR ("incidental catch\*" PRE/3 "affected by") OR ("incidental catch\*" PRE/3 "changed by")

OR ("marine mammal\*" PRE/3 "impacted by") OR ("marine mammal\*" PRE/3 "challenged by") OR ("marine mammal\*" PRE/3 "influenced by") OR ("marine mammal\*" PRE/3 "affected by") OR ("marine mammal\*" PRE/3 "changed by")

OR ("seabird\*" PRE/3 "impacted by") OR ("seabird\*" PRE/3 "challenged by") OR ("seabird\*" PRE/3 "influenced by") OR ("seabird\*" PRE/3 "affected by") OR ("seabird\*" PRE/3 "changed by")

)

AND

TITLE-ABS-KEY(

(fishing PRE/3 effect\*) OR (fishing PRE/3 impact\*) OR(fishing PRE/3 challeng\*) OR(fishing PRE/3 influenc\*) OR(fishing PRE/3 affect\*) OR(fishing PRE/3 chang\*)

OR (fisher\* PRE/3 effect\*) OR (fisher\* PRE/3 impact\*) OR(fisher\* PRE/3 challeng\*) OR(fisher\* PRE/3 influenc\*) OR(fisher\* PRE/3 affect\*) OR(fisher\* PRE/3 chang\*)

OR ("impacted by" PRE/3 fishing) OR("challenged by" PRE/3 fishing) OR("influenced by" PRE/3 fishing) OR("affected by" PRE/3 fishing) OR("changed by" PRE/3 fishing)

OR ("impacted by" PRE/3 fisher\*) OR("challenged by" PRE/3 fisher\*) OR("influenced by" PRE/3 fisher\*) OR("affected by" PRE/3 fisher\*) OR("changed by" PRE/3 fisher\*)

)

AND

 TITLE-ABS-KEY (

"North Sea" OR "wadden sea" OR "Baltic" OR "Atlantic Ocean" OR "North-East Atlantic" OR "Kattegat" OR "Skagerrak" OR "European waters" OR "Celtic Sea" OR "Irish Sea" OR "Bay of Biscay" OR "English Channel"

)

AND PUBYEAR AFT 2000

**Review 2. Ecosystem Effects on Fisheries**

*Objective*

Review ecosystem effects on fisheries’ resources. This includes impacts resulting from environmental changes (e.g. driven by climate) on the target species and their catchability. In this case, the target is ‘sustainable’, the ecosystem component is ‘fish target species’, and the impacting agent is ‘the environmental change’. For this example, the ecosystem challenge defines as ‘sustainable harvest of fish being degraded by changing environmental conditions’, and the primary question framing the determinants of the literature search will be ‘how, at what scale, and to what extent is the fish affected by the changing conditions?’. In addition, the scale component searches for the spatial and time resolutions (e.g., individual, stage, population). For example, a search query here might look like (“marine habitat” OR “seafloor” OR “benthos” OR “foodwebs”, etc.) AND (“fish” OR “target fish” OR “fisheries´resources” OR “fishing opportunities”, etc.) AND (“productivity” OR “fishing mortality” OR “SSB”, etc.) combining pressures on the fisheries resources, ecosystem component states, and indicators.

*Challenges*

An ecosystem challenge here defines a change in the marine environment of the marine species (target fish) induced by the fishing or beyond (incidental (by)catch, other marine foodweb components, biogeochemical marine components, but excluding other human activities than fishing) that is significant enough to affect the current or future fishing opportunities severely. The management measures should take up these challenges by implementing actions that would negate or minimise the impacts.

*General Structure*

[Species] AND [Environmental Driver] AND [Geographic Limitation]

*Explanation*

“Species” is a list of those species whose stocks were identified in Task 2. For each species, their common and scientific name are included using “OR”. “Environmental Driver” is a select list of GOOS environmental factors. “Geographic Limitation” is a list of terms describing the common names of the areas relevant to the project(s).

*Scopus-specific query syntax*

TITLE-ABS-KEY(

"fisheries" OR "fishery" OR "fish\* opportunit\*" OR "fishing" OR ( "fisher\*" AND "revenue\*" ) OR ( "fisher\*" AND "profit\*" ) OR ( "fisher\*" AND "income\*" )

)

AND

TITLE-ABS-KEY(

(polic\* PRE/3 impact\*) OR(polic\* PRE/3 challeng\*) OR(polic\* PRE/3 influenc\*) OR(polic\* PRE/3 affect\*) OR(polic\* PRE/3 chang\*)

OR (socio\* PRE/3 impact\*) OR(socio\* PRE/3 challeng\*) OR(socio\* PRE/3 influenc\*) OR(socio\* PRE/3 affect\*) OR(socio\* PRE/3 chang\*)

OR (institution\* PRE/3 impact\*) OR(institution\* PRE/3 challeng\*) OR(institution\* PRE/3 influenc\*) OR(institution\* PRE/3 affect\*) OR(institution\* PRE/3 chang\*)

OR (decisionmak\* PRE/3 impact\*) OR(decisionmak\* PRE/3 challeng\*) OR(decisionmak\* PRE/3 influenc\*) OR(decisionmak\* PRE/3 affect\*) OR(decisionmak\* PRE/3 chang\*)

OR (legislati\* PRE/3 impact\*) OR(legislati\* PRE/3 challeng\*) OR(legislati\* PRE/3 influenc\*) OR(legislati\* PRE/3 affect\*) OR(legislati\* PRE/3 chang\*)

OR (governance PRE/3 impact\*) OR(governance PRE/3 challeng\*) OR(governance PRE/3 influenc\*) OR(governance PRE/3 affect\*) OR(governance PRE/3 chang\*)

OR (management PRE/3 impact\*) OR(management PRE/3 challeng\*) OR(management PRE/3 influenc\*) OR(management PRE/3 affect\*) OR(management PRE/3 chang\*)

OR ("impacted by" PRE/3 polic\*) OR("challenged by" PRE/3 polic\*) OR("influenced by" PRE/3 polic\*) OR("affected by" PRE/3 polic\*) OR("changed by" PRE/3 polic\*)

OR ("impacted by" PRE/3 socio\*) OR("challenged by" PRE/3 socio\*) OR("influenced by" PRE/3 socio\*) OR("affected by" PRE/3 socio\*) OR("changed by" PRE/3 socio\*)

OR ("impacted by" PRE/3 institution\*) OR("challenged by" PRE/3 institution\*) OR("influenced by" PRE/3 institution\*) OR("affected by" PRE/3 institution\*) OR("changed by" PRE/3 institution\*)

OR ("impacted by" PRE/3 decisionmak\*) OR("challenged by" PRE/3 decisionmak\*) OR("influenced by" PRE/3 decisionmak\*) OR("affected by" PRE/3 decisionmak\*) OR("changed by" PRE/3 decisionmak\*)

OR ("impacted by" PRE/3 legislati\*) OR("challenged by" PRE/3 legislati\*) OR("influenced by" PRE/3 legislati\*) OR("affected by" PRE/3 legislati\*) OR("changed by" PRE/3 legislati\*)

OR ("impacted by" PRE/3 governance) OR("challenged by" PRE/3 governance) OR("influenced by" PRE/3 governance) OR("affected by" PRE/3 governance) OR("changed by" PRE/3 governance)

OR ("impacted by" PRE/3 management) OR("challenged by" PRE/3 management) OR("influenced by" PRE/3 management) OR("affected by" PRE/3 management) OR("changed by" PRE/3 management)

)

AND

 TITLE-ABS-KEY (

"North Sea" OR "Baltic" OR "North-East Atlantic" OR "Kattegat" OR "European waters" OR "Celtic Sea" OR "Irish Sea" OR "Bay of Biscay" OR "English Channel"

)

**Review 3. Social System Effects on Fisheries**

*Objective*

Review influence of social, economic and governance aspects on fisheries and fisheries management. This includes misfit or legislative (link to Task 1) and institutional challenges. For example, good ocean governance or fisheries management can be compromised by a mismatch in scale, e.g. when changing climate impacts in ocean operate on time horizons that are longer than those of specific institutional processes. Socio-economic ecosystem challenges could arise from fishing communities and their social fabrics related to specific fisheries impacted by a change in these fisheries’ resources or opportunities. The primary question framing the determinants of the literature search will be ‘how and to what intensity are the fisheries affected by socioeconomics?’.

*Challenges*

An ecosystem challenge here defines as a change in the framing of the fishing activity (social, economics, institutional settings, or fishing opportunities(?)) that impacts the socioeconomic viability of the fishing severely.

*General Structure*

[Impacted component] AND [Impacting component] AND [Impact] AND [Geographic Limitation]

*Explanation*

“Impacted component” is the list of social and economic related fisheries aspects including “Fishing economics” “profitability” “Coastal social fabrics” etc.. “Impacting component” is the list of type of factors that has the potential power to coerce the fishing, including “Fisheries management”, “Ocean governance”, “External economic factors” etc. We limit the search to a specific geographic area because we expect institutional settings and economics to be rather region-specific.

*Scopus-specific query syntax*

TITLE-ABS-KEY(

(

"fisheries" OR "fishery" OR "fish\* opportunit\*" OR "fishing" OR ( "fisher\*" AND "revenue\*" ) OR ( "fisher\*" AND "profit\*" ) OR ( "fisher\*" AND "income\*" )

)

AND NOT "freshwater\*" AND NOT "aquaculture\*" AND NOT "paleo\*"

)

AND

TITLE-ABS-KEY(

("ecosystem effect\*" PRE/3 impact\*) OR("ecosystem effect\*" PRE/3 challeng\*) OR("ecosystem effect\*" PRE/3 influenc\*) OR("ecosystem effect\*" PRE/3 affect\*) OR("ecosystem effect\*" PRE/3 chang\*)

OR (ecosystem PRE/3 impact\*) OR(ecosystem PRE/3 challeng\*) OR(ecosystem PRE/3 influenc\*) OR(ecosystem PRE/3 affect\*) OR(ecosystem PRE/3 chang\*)

OR (environmental\* PRE/3 impact\*) OR(environmental\* PRE/3 challeng\*) OR(environmental\* PRE/3 influenc\*) OR(environmental\* PRE/3 affect\*) OR(environmental\* PRE/3 chang\*)

OR ("environmental driver\*" PRE/3 impact\*) OR("environmental driver\*" PRE/3 challeng\*) OR("environmental driver\*" PRE/3 influenc\*) OR("environmental driver\*" PRE/3 affect\*) OR("environmental driver\*" PRE/3 chang\*)

OR ("marine envir\*" PRE/3 impact\*) OR("marine envir\*" PRE/3 challeng\*) OR("marine envir\*" PRE/3 influenc\*) OR("marine envir\*" PRE/3 affect\*) OR("marine envir\*" PRE/3 chang\*)

OR ("impacted by" PRE/3 ecosystem) OR("challenged by" PRE/3 ecosystem) OR("influenced by" PRE/3 ecosystem) OR("affected by" PRE/3 ecosystem) OR("changed by" PRE/3 ecosystem)

OR ("impacted by" PRE/3 "ecosystem effect\*") OR("challenged by" PRE/3 "ecosystem effect\*") OR("influenced by" PRE/3 "ecosystem effect\*") OR("affected by" PRE/3 "ecosystem effect\*") OR("changed by" PRE/3 "ecosystem effect\*")

OR ("impacted by" PRE/3 environmental\*) OR("challenged by" PRE/3 environmental\*) OR("influenced by" PRE/3 environmental\*) OR("affected by" PRE/3 environmental\*) OR("changed by" PRE/3 environmental\*)

OR ("impacted by" PRE/3 "environmental driver\*") OR("challenged by" PRE/3 "environmental driver\*") OR("influenced by" PRE/3 "environmental driver\*") OR("affected by" PRE/3 "environmental driver\*") OR("changed by" PRE/3 "environmental driver\*")

OR ("impacted by" PRE/3 "marine envir\*") OR("challenged by" PRE/3 "marine envir\*") OR("influenced by" PRE/3 "marine envir\*") OR("affected by" PRE/3 legislati\*) OR("changed by" PRE/3 "marine envir\*")

)

AND

 TITLE-ABS-KEY (

"North Sea" OR "Baltic" OR "North-East Atlantic" OR "Kattegat" OR "European waters" OR "Celtic Sea" OR "Irish Sea" OR "Bay of Biscay" OR "English Channel"

)

AND PUBYEAR AFT 2010

**Data extraction from the papers and pseudocode**

* Quality of the study (data coverage, representativeness, appropriateness etc.)
* Time and spatial scale (individual/stage/population/stock/coastal/offshore/ecoregion)
* Observation instruments (the type of data and data treatment)
* State and pressure Indicators measured
* The research question and a priori challenge
* Is any a priori impact threshold described
* Direction (negative/positive) and magnitude of the impact
* If a threshold does not exist, and the authors flagged the pressure as a possible issue, then we will be identifying an ecosystem effect posing a challenge
* If a threshold does not exist, and an impact is greater than a defined threshold then a quantified challenge is being identified
* Fisheries addressed in the paper e.g. North Sea demersal fisheries
* The challenge addressed in the paper could be encoded so that it will be common among reviewers and avoid inconsistency if run in parallel: The Review\_ID, the impacted\_component, the impacting\_component, the geographical\_limitation, the type\_of\_challenge (review 1, 2 or 3), the time\_scale, the spatial\_scale, the type\_of\_fishery.
* Repeat previous steps if several impacts identified in the same paper
* When all papers have been screening the list of challenges is the list of unique codes of all the encoded challenges. The identified challenges are pooled by expert knowledge and categorized in a hierarchy of levels
* Assign challenge\_IDs and tabulate papers per challenges IDs. One paper can be listed within several challenge IDs.