DELIVERABLE 4.1

Report on the key species and habitats impacted by fishing

Version 2.0

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SEAWISE

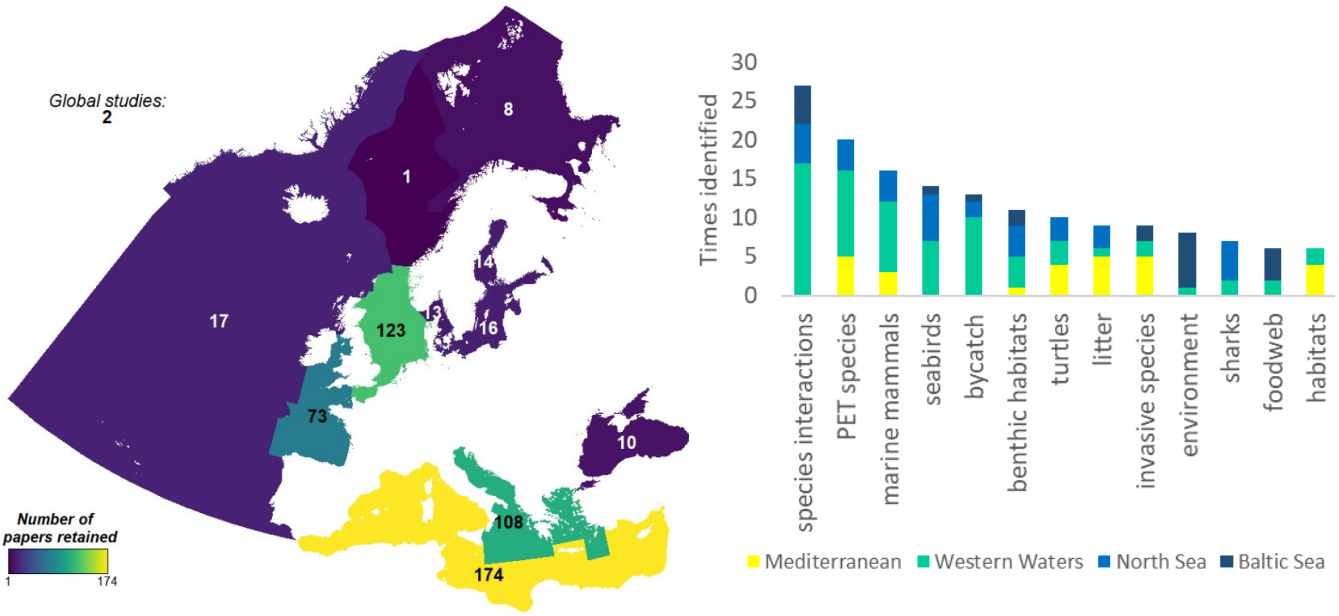
Executive summary

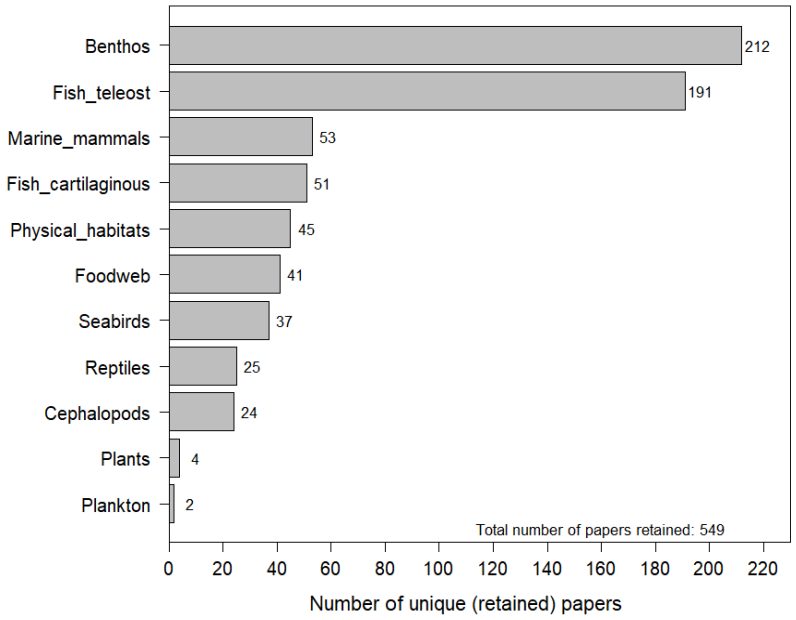
The implementation of ecosystem-based fisheries management requires knowledge on the ecological impact of fishing activities on species and their habitats – those both targeted and not targeted by fisheries. To identify which ecological impacts are key and what is known about them, SEAwise consulted stakeholders through European Advisory Councils and conducted a systematic review of the scientific literature to map the available knowledge and evidence. Specific reference was given to the bycatch of Protected, Endangered and Threatened (PET) species, benthic habitats, food webs and biodiversity, and impact from fisheries-related litter and ghost nets.

At the stakeholder consultations, sharks and/or elasmobranchs, turtles, species interactions, and seals or marine mammals were identified as top ranked in at least three out of the five regions. Other terms identified by at least two Case Study regions were: seabirds, sensitive species, benthic habitats, litter, PET species, invasive species and species interactions.

Relevant data were extracted from 549 retained papers. The majority of studies were conducted in the Mediterranean Sea, whereas only few papers reported on fishing impacts in the Baltic Sea (see figure below). Bony fish (teleosts) and benthos were the most studied ecosystem components in all Case Study regions, whereas marine mammals and cartilaginous fish were often studied in relation to bycatch of PET species. Out of the 549 papers, most of them were related to fishing impacts on food webs and biodiversity and benthic habitats, followed by bycatch of PET species and other fishing impact studies (not related to any task). Fewest studies were related to the impact of fisheries-related litter and ghost nets. Demersal trawls were by far the most studied gear in studies on commercial fishing impacts. For recreational fisheries, hooks and lines, in particular angling, was the most studied fishing activity.

Among the items identified by the stakeholders, marine mammals, seabirds and reptiles were all covered in at least 25 papers each, indicating that there is a considerable body of knowledge even though not all areas may have information for all species. Litter was the key item that was least frequently reported on in the literature, especially outside the Mediterranean, where scientific papers were rare. As a consequence, areas outside the Mediterranean may lack information for further analysis unless a dedicated effort is made in SEAwise to remedy this. The regional differences in topics identified by stakeholder scoping did not reflect the regional amount of papers available.





Key species and habitats impacted by fishing

Number of papers registered by region (top left) and ecological item (bottom left) and ecological issues identified by most stakeholders as key (top right).

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1. SEAwise background

The SEAwise project works to deliver a fully operational tool that will allow fishers, managers, and policy makers to easily apply Ecosystem Based Fisheries Management (EBFM) in their own fisheries. With the input from advice users, SEAwise identifies and addresses core challenges facing EBFM, creating tools and advice for collaborative management aimed at achieving long-terms goals under

environmental change and increasing competition for space. SEAwise operates through four key stages, drawing upon existing management structures and centred on stakeholder input, to create a comprehensive overview of all fisheries interactions in the European Atlantic and Mediterranean. Working with stakeholders, SEAwise acts to:

- Build a network of experts - from fishers to advisory bodies, decision makers and scientists - to identify widely-accepted key priorities and co-design innovative approaches to EBFM.
- Assemble a new knowledge base, drawing upon existing knowledge and new insights from stakeholders and science, to create a comprehensive overview of the social, economic, and ecological interactions of fisheries in the European Atlantic and Mediterranean.
- Develop predictive models, underpinned by the new knowledge base, that allow users to evaluate the potential trade-offs of management decisions, and forecast their long term impacts on the ecosystem.
- Provide practical, ready-for-uptake advice that is resilient to the changing landscapes of environmental change and competition for marine space.

The project links the first ecosystem-scale impact assessment of maritime activities with the welfare of the fished stocks these ecosystems support, enabling a full-circle view of ecosystem effects on fishing productivity in the European Atlantic and Mediterranean. Drawing these links will pave the way for a whole-ecosystem management approach that places fisheries at the heart of ecosystem welfare. In four cross-cutting case studies, each centered on the link between social and economic objectives, target stocks and management at regional scale SEAwise provides:

- Estimates of impacts of management measures and climate change on fisheries, fish and shellfish stocks living close to the bottom, wildlife bycatch, fisheries-related litter and conflicts in the use of marine space in the Mediterranean Sea,
- Integrated EBFM advice on fisheries in the North Sea, and their influence on sensitive species and habitats in the context of ocean warming and offshore renewable energy,
- Estimates of effects of environmental change on recruitment, fish growth, maturity and production in the Western Waters,
- Key priorities for integrating changes in productivity, spatial distribution, and fishers' decision-making in the Baltic Sea to create effective EBFM prediction models.

Each of the four case studies will be directly informed by expert local knowledge and open discussion, allowing the work to remain adaptive to change and responsive to the needs of advice users.

1.1 The role of this deliverable

This deliverable report describes the approach taken to complete steps 1 and 2 of the SEAwise EBFM in relation to the ecological impacts of fishing:

1. Identify the stakeholder community, and with them, maps of the ecoregions, their species and habitats, and stakeholder interests;

2. Identify the key and habitats are identified along with the factors most likely to impact them based on a systematic review.

1.2 Contributors

The contributors to this deliverable included the Task 1.2 lead, WP4 lead, Task 4.1 lead, case study leads, scoping consultation participants, key review drivers and reviewers. The leads and key review drivers coordinated the communication among the 31 reviewers. The x.1 leads and key review drivers, in particular Task 3.1 and 5.1 leads were instrumental in defining and selecting search key words and data extraction fields for Task 4.1, by sharing methods and perceptions. Names and institutions of people involved in these roles are given in Table 1.1.

Table 1.1 Names and roles of contributors to this deliverable.

Name	Institute	Scoping	Key Review driver	Reviewer
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Ole Ritzau Eigaard	DTU Aqua			X
Nis Sand Jacobsen	DTU Aqua	X		
Elliot John Brown	DTU Aqua	X	X	X
Marie Savina-Rolland	Ifremer	X	X	
Raphael Girardin	Ifremer			X
Ghassen Halouani	Ifremer			X
Oihane Cabezas Basurko	AZTI			X
Miren Altuna	AZTI			X
Dorleta Garcia	AZTI	X		X
Amaia Astarloa	AZTI			X
David Reid**	MI	X		X
Sebastian Uhlmann	MI		X	X
Maria Teresa Spedicato	COISPA	X		X
Giovanni Romagnoni	COISPA			X
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Name	Institute	Scoping	Key Review driver	Reviewer
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Marc Taylor	TI-SF	X		
Gert Van Hoey	EV-ILVO			X
Felien Festjens	EV-ILVO			X
Stephie Seghers	EV-ILVO			X
Jochen Depestele	EV-ILVO	X		
Marloes Kraan	WR	X		
Chris Lynam	CEFAS	X		
Joanna Bluemel	CEFAS			X
Robert Thorpe	CEFAS			X
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Søren Eliasen	CBG-AAU	X		
Angelos Plataniotis	AUEB		X	
Mikaëla Potier	Agrocampus Ouest			X
Logan Binch	WU			X
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* Task lead

** WP lead

1.3 Acronyms and abbreviations

CS	Case Study
EBFM	Ecosystem Based Fisheries Management
DOI	Digital Object Identifier
PDF	Portable Document Format
PET	Protected, Endangered and Threatened
WP	Work Package
x.1	All review tasks for work packages two through six

2. Aims of scoping and systematic reviews

The SEAwise stakeholder integration aims to ensure that the key issues of relevance for the social system and potential management measures are identified and prioritised for further evaluation in the project and hence that the end results are relevant to the end users. The SEAwise scoping consultations in the first half year of the project had the following specific aims:

- To build trust and a common understanding between SEAwise participants and identified stakeholders;
- To identify key issues of relevance for ecosystem based fisheries advice, current ecosystem status and potential management measures;
- To identify priorities of these key issues and evaluate how this varies between individuals;
- To compare results between regions and group sessions;
- To compare results between different scoping methods within a Case Study region.

The methods used in scoping consultations are described in Deliverable D1.1.

In developing and implementing operational EBFM, SEAwise is building upon years of knowledge and research, which is both rich and sparse, depending on the subject area, geographical area and ecosystem components in question. The aim of the systematic review is to collate the knowledge on the key environmental drivers of commercial species productivity in our four case studies, and the processes they act on through the application of standardised methods described in Deliverable 1.1. Systematic Reviews provide exhaustive summaries of current knowledge and clearly document the methods used. The reviews are performed in four steps: 1. framing of research question, 2. identification of relevant work, 3. assessment of the quality of studies, and 4. summary of the evidence and interpretation of the findings. The approach provides transparency and allows later updates as more information becomes available. Together with the scoping consultations, the reviews will identify key relevant drivers of commercial species productivity and scenarios of future development in these drivers.

3. Scoping consultations

The aim of the stakeholder consultation will impact the choice of the most appropriate consultation method. The choice of consultation method was therefore carefully considered in advance. Specific attention was given to minimise the impact of the organising scientists' expectations and emergent group dynamics on group results. Comparability of results was ensured by using common methods in all regions and group sessions.

Three different approaches was used to identify key issues of relevance, current ecosystem status and potential management measures (Individual consultation, individual consultation in a group environment and group consultation). Two approaches used to identify priorities of these key issues and evaluate how this varies between individuals (Individual consultation, individual consultation in a group environment). The combination of these methods allowed the identification of key priorities with and without group dynamics. The key issues were discussed in further detail in a group consultation to allow a common understanding of their definition. Further details about the methods can be found in deliverable report D1.9.

3.1 Mediterranean Sea scoping

The words relevant to ecosystem effects of fishing and identified by at least two of the consulted stakeholders were PET species, litter, habitats, invasive species, marine mammals, turtles, elasmobranchs and predation (Fig. 3.1). Noticeably benthic habitats, food webs and biodiversity were identified by none or one stakeholder but six to ten project participants. However, two other stakeholders identified seabed degradation and VMEs, respectively and marine mammals, PET species, turtles and elasmobranchs are important components of biodiversity.

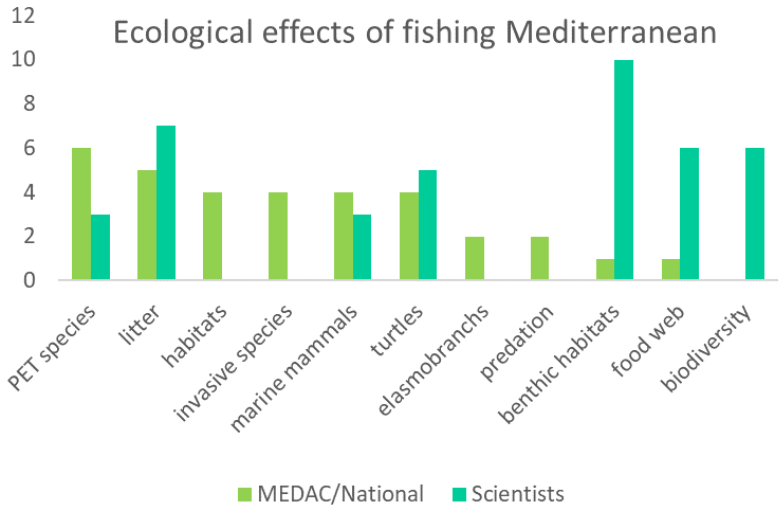


Fig. 3.1 Words most commonly identified for ecological effects of fishing in the scoping exercises. Frequency of occurrence among the SEAwise scientists are given for comparison.

3.2 Western Waters scoping

The words relevant to ecosystem effects of fishing and identified by at least three of the stakeholders consulted were marine mammals, bycatch, species interactions, seabirds, PET/sensitive species, benthic habitats, biodiversity, elasmobranchs, turtles and sharks (Fig. 3.2).

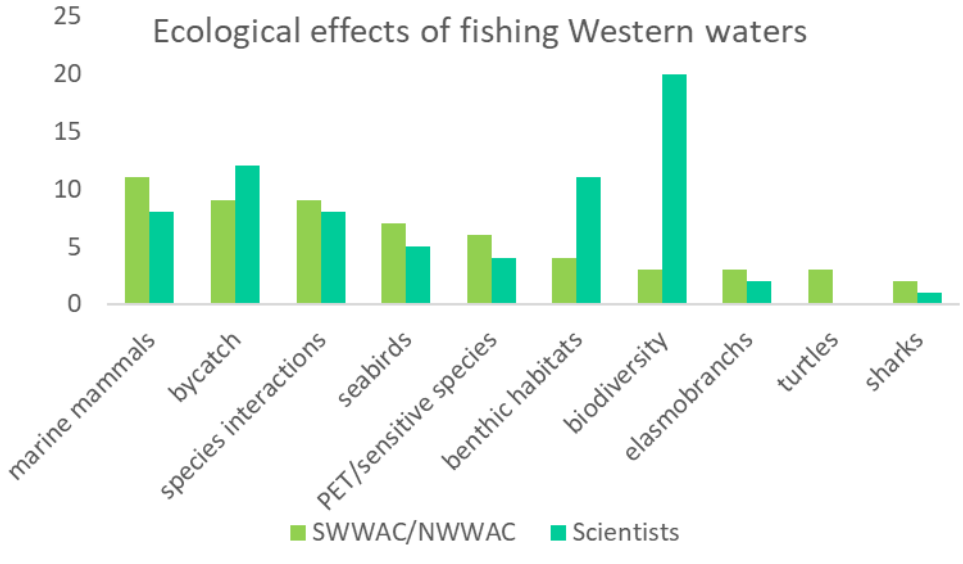


Fig. 3.2 Words most commonly identified for ecological effects of fishing in the scoping exercises. Frequency of occurrence among the SEAwise scientists are given for comparison.

3.3 North Sea scoping

The words relevant to ecosystem effects of fishing and identified by at least three of the stakeholders consulted were seabirds, sharks, benthic habitats, marine mammals, sensitive species, species interactions, litter and turtles (Fig. 3.3). Among the scientists, food web, habitat degradation, biodiversity and eutrophication were also listed.

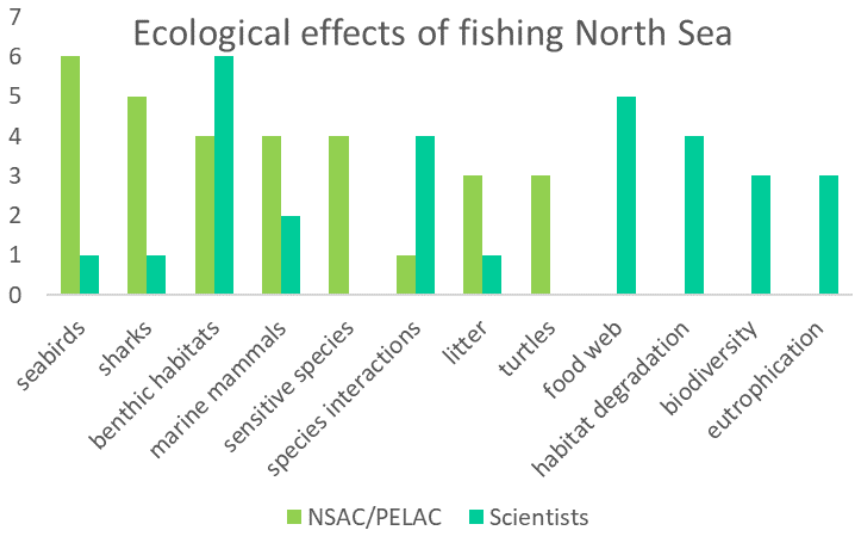


Fig. 3.3 Words most commonly identified for ecological effects of fishing in the scoping exercises. Frequency of occurrence among the SEAwise scientists are given for comparison.

3.4 Baltic Sea scoping

The words relevant to ecosystem effects of fishing and identified by at least two of the stakeholders consulted were species interactions, food web, benthic habitats and invasive species. Among the scientists, nutrients, seals, habitat quality and predation were also listed (Fig. 3.4).

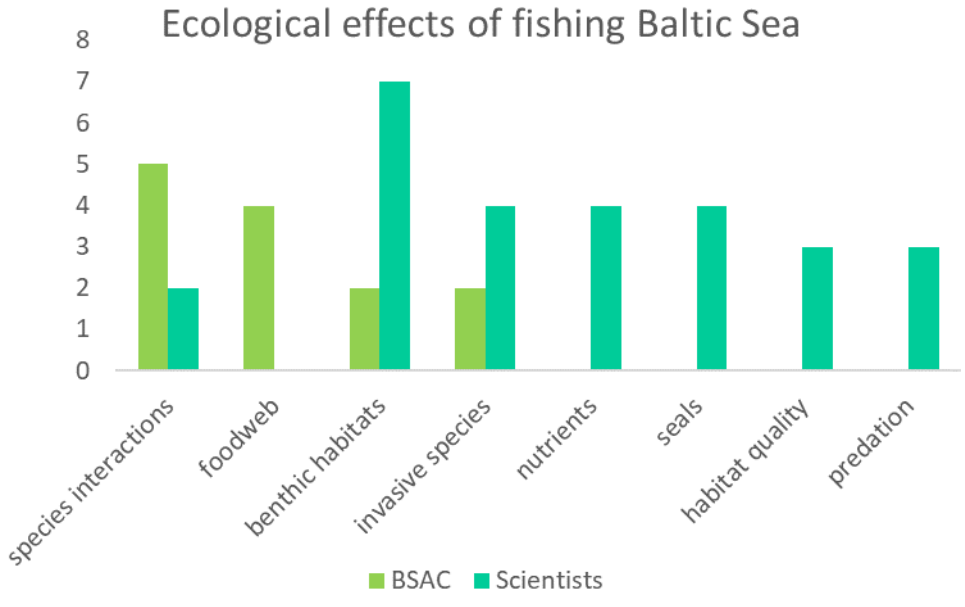


Fig. 3.4 Words identified for WP4 aspects in the scoping exercises.

3.5 Scoping results across all areas

The words relevant to ecosystem effects of fishing identified by most stakeholders consulted were species interactions, PET/sensitive species, marine mammals, seabirds, bycatch, benthic habitats, turtles, litter, invasive species and environment (Figure 3.5).

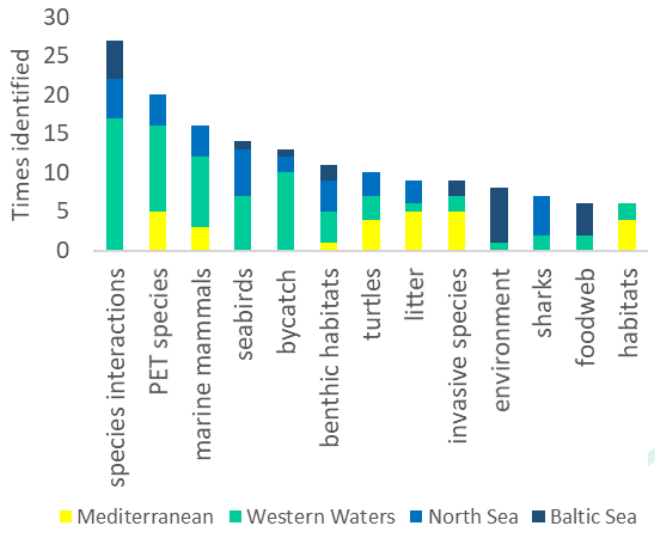


Fig. 3.5 Words identified for WP4 aspects in the scoping exercises ordered by frequency of occurrence among stakeholder input.

4. Systematic reviews

The implementation of ecosystem-based fisheries management requires knowledge on the ecological impact of fishing activities on species and their habitats. This includes the impact of extracting biomass from the ecosystem on populations that are targeted by fisheries, but also any other direct or indirect impact caused by fishing on species and habitats (together called 'ecosystem components'). A large body of literature on such impacts exists, yet a systematic approach is needed to synthesize this information and to identify the key species and habitats that are impacted, including the factors that impact them.

The systematic reviews provide exhaustive summaries of current knowledge and clearly document the methods used. The approach provides transparency and allows later updates as more information becomes available and is described in more detail below. The systematic reviews encompass five steps:

- Framing of the research question
- Scoping to define search terms
- Screening of studies
- Data extraction
- Interpretation of the findings

Following these steps, a discussion of potential biases is added together with a presentation of the outcome of the systematic review. The literature review methodology is described in detail in Deliverable 1.1. Only a summary and WP4 specificities are provided here. Specific reference was given to the topics of Task 4.2-4.5: (i) bycatch of Protected, Endangered and Threatened (PET) species, (ii) benthic habitats, (iii) food webs and biodiversity, and (iv) impact from fisheries-related litter and ghost nets.

The literature review was conducted by a team of 31 persons from 11 different institutions. The papers identified in the search were allocated to the participants for screening, which means that they had to read the title, the abstract and the keywords of the papers in their list and decide whether to include or exclude them for the next phase (data extraction), according to specific exclusion criteria shared with them. Included papers had to be labelled according to the WP4 task they related to. The included papers were allocated to the participants who then assessed the full text of each paper, and either excluded them, according the same criteria as in the screening phase, or extracted information from the paper, according to the data extraction template. After the collection of the individual data extraction results, the information was combined and processed.

The output of the systematic review is a query-able database of scientific articles and evidence of the impact (or lack of it) on ecosystem components by fisheries and a range of pressures exerted by fisheries. Ecosystem components, fisheries and pressures are classified in broad categories as well as in more specific ones, allowing one to select the knowledge available on the impact of a specific pressure or fishery on a specific ecosystem component. The database is therefore readily available for further downstream use in the project.

4.1 Framing of the research question

The systematic review was undertaken to map the available knowledge and evidence of impacts of commercial and recreational fisheries on key species and habitats across European sea basins.

4.2 Scoping to define search terms

The scoping process used to determine key issues with stakeholders (see description in section 3 and deliverable 1.9 for participant number and gender balance) was also used by the scientists in SEAwise in isolation. Based on the results from this exercises, the participants in the systematic review for WP4 defined a list of spatial extents, ecosystem components, pressures, impact and fishing gears. Starting from this**Error! Reference source not found.**, the search terms were defined collectively and organised into five categories (**Error! Reference source not found.**).

A search string was constructed including spatial extent, ecosystem components, pressures, impact and fishing gears. Instead of one search by Case Study, it was decided to conduct one European-wide search, as it was foreseen that case study-specific searches would lead to many knowledge gaps. Search terms for each element in the search string were selected based on the scoping exercises by Case Study (not to be confused with the stakeholder consultations), expert input (coming from the WP4 task leads) and synonyms.

The search was conducted in Scopus and Web of Science. An additional search was done later on focussing on a specific regional sea only that was not included in the main search. Search records were combined and any duplicates removed. A detailed description of the construction of the search string and the search strategy can be found in Deliverable 1.1.

Table 4.1 Search terms by element used to construct the search string. Elements were separated by 'AND'. Within each element, terms were separated by 'OR'.

SPATIAL	ECOSYSTEM COMPONENT	PRESSURE	IMPACT	GEAR
Adriatic Sea	marine mammal*	fishing	effect	trawl*
Aegean Sea	cetacea*	fishery	influenc*	dredg*
Aegean-Levantine Sea	seal*	fisheries	impact*	seine*
Baltic Sea	pinniped*	overfish*	affect*	pot
Baltic Proper	whale*	overexploit*	chang*	trap*
Kattegat	dolphin*	fishing gear*	disturb*	net
Barents Sea	porpoise*	gear selectivity	risk	gillnet

SPATIAL	ECOSYSTEM COMPONENT	PRESSURE	IMPACT	GEAR
Black Sea	seabird*	selectiv*	interact*	hook-and-line
Cantabrian Sea	fish	bycatch		hookandline
Eemian Sea	fishes	by-catch		longline*
English Channel	demersal*	bycaught		angl*
West Coast of Scotland	pelagic*	by-caught		spearfish*
Ionian Sea	elasmobranch*	discard*		
Ligurian Sea	shark*	surviv*		
Malin Sea	ray*	unaccounted mortality		
Mediterranean Sea	skate*	recreational fish*		
North Sea	cephalopod*	litter		
Skagerrak	octopus	entangl*		
Tyrrheanian Sea	squid*	ingest*		
Bay of Biscay	cuttlefish			
Celtic Sea*	reptile*			
Irish Sea	turtle			
Norwegian Sea	benthos			
European waters	benthic habitat			
North*east Atlantic	benthic communit*			
Western Mediterranean	infauna*			
Alboran Sea	epifauna*			
Balearic Sea	macrobenthos			
Sea of Sicily	shellfish			
Strait of Sicily	mussel*			
	coral*			
	seabed			
	sediment			
	mud			
	sand			
	reef*			
	rock*			
	gravel			
	algae			
	algal bloom*			
	phytoplankton			
	zooplankton			
	copepod*			
	water column			
	macrophyt*			
	marcoalga*			
	seaweed*			
	seagrass*			
	eelgrass			
	foodweb			
	food web			
	trophic guild*			
	primary produc*			
	secondary produc*			
	filter feed*			

SPATIAL	ECOSYSTEM COMPONENT	PRESSURE	IMPACT	GEAR
	deposit feed*			
	planktivor*			
	herbivor*			
	detritus feed*			
	detritivor*			
	predator			
	vulnerable species			
	PET species			
	essential fish habitat*			
	nurser*			
	juvenile habitat*			
	sensitive habitat*			
	Ammodyt*			
	Aristaeomorpha foliacea			
	Aristeus antennatus			
	Clupea harengus			
	Dicentrarchus labrax			
	Engraulis encrasicolus			
	Flatfish			
	Gadoids			
	Gadus morhua			
	Lepidorhombus whiffiagonis			
	Lophius			
	Melanogrammus aeglefinus			
	Merlangius merlangus			
	Merluccius merluccius			
	Mullus barbatus			
	Mullus surmuletus			
	Neogobius melanostomus			
	Nephrops norvegicus			
	Parapenaeus longirostris			
	Platichthys flesus			
	Platichthys solemdali			
	Pleuronectes platessa			
	Pollachius pollachius			
	Pollachius virens			
	Salmo salar			
	Salmo trutta			
	Sardina pilchardus			
	Scomber scombrus			
	Solea solea			
	Sprattus sprattus			
	Trachurus trachurus			
	Trisopterus esmarkii			

Search results

The Scopus and Web of Science searches using the specified search strings (see Deliverable D1.1) returned 1,976 and 593 records, respectively (all together 2,569 records). Removing 518 duplicated papers led to a total of 2,051 unique papers (Table 4.2).

Table 4.2 Number of search records by search, duplicates and total number of search records. The two additional searches focussed on a specific regional sea that was not included in the two main searches.

Search	Number of records
E4 Scopus 10-01-2022	1,952
E4 Web of Science 10-01-2022	588
E4 Scopus 04-02-2022 (additional)	24
E4 Web of Science 04-02-2022 (additional)	5
Total	2,569
Duplicates	518
Total without duplicates	2,051

Potential Biases

The search string has likely limited the number of relevant papers. The Gear element was added to the search string, requiring titles and/abstract to explicitly name the fishing gear that was studied. This resulted in a large reduction of irrelevant papers (e.g. 'fishing' was mentioned but not studied), but also in a reduction of relevant papers that studied fishing impacts yet without mentioning the specific fishing gears studied in the title, abstract or keywords. Although these papers may provide interesting general information, they may not be useful in the subsequent management strategy evaluations in SEAwise.

4.3 Screening of studies

All records were double-screened by title and abstract and either excluded when one or more of a set of pre-defined exclusion criteria applied, or included when none of the exclusion criteria applied. Included papers were labelled according to the topics of Tasks 4.2-4.5. Any disagreement between two reviewers was reconciled by a third reviewer. Included papers were assessed for their full text by one reviewer each. Relevant data were extracted and entered into a data extraction form. After reviewers completed their data extraction, all forms were merged, forming the database. Extracted data were analysed and summarized, and are presented in the sections below.

The 2,051 unduplicated search records were double-screened by title and abstract according to the exclusion criteria and inclusion labels. There was 62% agreement between reviewers. Note that lack of agreement involved both disagreement on inclusion or exclusion, but also on agreement on inclusion or exclusion but with disagreement on the criteria or labels applied. After reconciling disagreements, 1,320 (64%) of the papers were excluded based on one or more exclusion criteria (Table 4.3). The vast majority of excluded papers (90%) was rejected based on the 'EXCLUSION on evidence' criterion, meaning that the topic of the paper was not relevant for the review. A small number of papers was rejected based on target group or study type (3%), environment or location (2%) or document type (1%). Only one paper was excluded based on language at this stage.

The remaining 731 papers (36%) were considered for data extraction (Table 4.3). The majority of included papers were labelled under Task 4.3 (29%), followed by Task 4.4 (23%), Task 4.2 (19%) and Task 4.5 (6%). Almost 24% of included papers did not relate explicitly to the WP4 tasks, yet were often still relevant to the topic of the review when considering target/non-target species.

*Table 4.3 Number of times and percentage of papers excluded and included during the **screening** phase. The total number of papers screened was 2,051.*

Criterion/label	Number of times	Percentage (%)
EXCLUDE on evidence	1254	89.9
EXCLUDE on target group	39	2.8
EXCLUDE on study type	37	2.7
EXCLUDE on environment	26	1.9
EXCLUDE on location	26	1.9
EXCLUDE on document type	12	0.9
EXCLUDE on language	1	0.1
Number of papers with multiple criteria	47	3.5
Number of unique papers excluded	**1,320**	**64.4**
INCLUDE on 4.2 bycatch PET species	146	19.2
INCLUDE on 4.3 benthic habitats	219	28.8
INCLUDE on 4.4 food webs and diversity	173	22.7
INCLUDE on 4.5 litter	42	5.5
INCLUDE on title and abstract	181	23.8
Number of papers with multiple labels	30	3.9
Number of unique papers included	**731**	**35.6**

Full Text Exclusions

During the data extraction phase, an additional 183 out of 731 (25%) papers were excluded (Table 4.4). Similar to the screening phase, the majority of rejections (84%) was excluded because the paper turned out not to be relevant to the review ('EXCLUDE on evidence'). A small number of papers was rejected based on study type (7%), language (3%), or location, document type or environment (2%) or target group (1%).

The number of included papers that remained was 549 (75%; Table 4.4). The majority of included papers were labelled under Task 4.4 (30%), followed by Task 4.3 (29%), Task 4.2 (19%) and Task 4.5 (5%). 17% of included papers did not relate to the WP4 tasks, yet were still deemed relevant to the topic of the review, because they often dealt with fishing impacts on target species of interest.

Potential Biases

Reviewers were instructed to select at least one exclusion criterion, being the one that stood out or was first detected, but it was not required to select multiple criteria if multiple applied. Therefore, not all potentially applicable exclusion criteria were reported. For the inclusion labels, reviewers were requested to choose only one label – being the one that fits best – but a second one was optional, if papers seems to be equally related to two tasks. This was particularly the case for papers studying fishing impacts on benthic communities: these were sometimes labelled under both Task 4.3 and 4.4, but most often labelled under Task 4.3, despite biodiversity (a Task 4.4 topic) being studied in some cases.

*Table 4.4 Number of times and percentage of papers excluded and included during the **data extraction** phase. The total number of papers reviewed during the data extraction phase was 731.*

Criterion/label	Number of times	Percentage (%)
EXCLUDE on evidence	153	84.1
EXCLUDE on study type	12	6.6
EXCLUDE on language	6	3.3
EXCLUDE on location	4	2.2
EXCLUDE on document type	3	1.6
EXCLUDE on environment	3	1.6
EXCLUDE on target group	1	0.5
Number of papers with multiple criteria	0	0
Number of unique papers excluded	**183**	**24.9**
INCLUDE on 4.2 bycatch PET species	114	19.4
INCLUDE on 4.3 benthic habitats	172	29.3
INCLUDE on 4.4 food webs and diversity	173	29.5
INCLUDE on 4.5 litter	28	4.8
INCLUDE on title and abstract	100	17.0
Number of papers with multiple labels	38	6.5
Number of unique papers included	**549**	**75.1**

4.4 Data extraction

During the data extraction phase, included papers from the screening phase were evaluated, based on their full text, whether any exclusion criteria applied and under which WP4 task they fit. Fig. 4.1 shows the ultimate fate of these papers, demonstrating that some included papers were assigned to another WP4 task during the data extraction phase.

Data based on the full text of included papers were extracted into a data extraction form template. The form consisted of three main parts: a Bibliographic section, a Common Section and a WP4-specific section. The Bibliographic section was pre-filled and included relevant bibliographic information (e.g. title, journal, abstract, DOI). The Common section was shared across the systematic reviews of all WPs. Here information was entered on exclusion criteria (if applicable), region and Case Study area, spatial and temporal scale and resolution, sampling method, analytical method used for inference, quality criteria (related to methods and spatial and temporal scale and resolution), concluding remarks and general comments.

The WP4-specific section consisted of five sub-sections: General, Ecosystem component, Pressure, Gear and Impact. In the General sub-section, the type of study was and the inclusion label as reported during the screening were entered, but the latter could be changed based on the full text assessment. In the Ecosystem component sub-section the species and/or habitat studied were specified. Filling in the broad biotic group was required (e.g. marine mammals, birds), as well as the scientific name of species studied. However, in case of many species studied, it was possible to enter taxonomic group at a higher level of organisation rather than the scientific name of each individual species.

In the Pressure sub-section, the type of pressure was entered: catch and bycatch, discarding (in the form of input of organic matter to the ecosystem), input of litter, physical disturbance of the seabed, electromagnetic input, noise or visual disturbance. If the type of pressure was 'catch and bycatch', a second column specified whether the impacted species were target species, non-target species or bycatch species. The paper was be the main guidance to specify this, but if this was not clear, participants should check whether species were on the list of Target Species as defined

during the scoping workshops (if yes, then 'target' – see also species listed in Table 4.1) or on the PET species list (if yes, then 'bycatch' – same list as used to decide on the inclusion label of Task 4.2). If the studied species was on neither list and it was not clear from the paper, it was classified as 'non-target'. In the Gear sub-section, the type of fishery was specified (commercial, recreational, scientific or unknown), as well as the type of gear (e.g. demersal trawls, seines, hook and lines).

The final sub-section on Impact started with a column where the response variable as reported in the paper was entered as free text. In the second column, the category was chosen under which the reported response variable fitted best. In the third column the direction of the relationship between the pressure variable and response was reported as positive, negative, multiple or no impact. In the last column free text could be added on the magnitude of the relationship as reported in the paper, such as on the significance of an effect or a relative measure in the authors' own words.

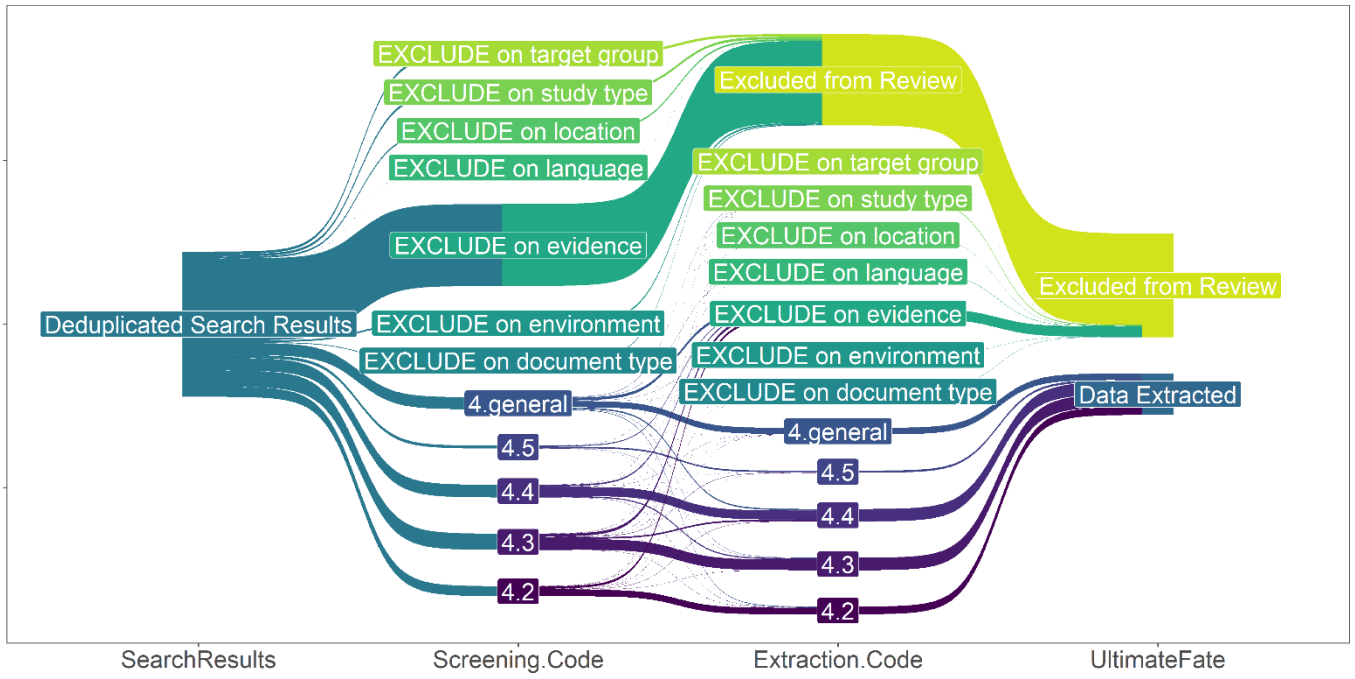


Fig. 4.1 Sankey diagram showing the fate of search records at each step of the systematic review.

Potential Biases

Despite a pre-test of the data extraction protocol and application of pre-defined rules, some potential biases during the data extraction phase were inevitable. These include a mismatch between the level of detail of reporting versus the level of extraction. For example, some studies provided species lists of fish or benthic communities, yet the individual species names were not extracted, but instead more general terms, such as 'demersal fish' or 'epifaunal community' were reported, as entering entire species lists would have taken a disproportional amount of time and is prone to errors (e.g. relating to copying and pasting, or spelling). Therefore, it is not possible to produce complete species list from the database, as not all species studied were consistently reported. Furthermore, there was some difference between reviewers in the detail of reporting on such matters (i.e. some being more elaborate than others).

Another bias observed was possible misinterpretation of the definitions of the data extraction elements. For example, some reviewers interpreted the Pressure type 'discarding' as the discarding of fish or benthos and the subsequent measured damage or mortality. However, such studies should have been classified under Pressure type 'Catch and bycatch'. Instead, discarding should have been only chosen for papers that studied discarding in the sense providing organic matter back to the ecosystem (i.e. as food for seabirds or scavenging benthos). A check and

correction of such possible misinterpretations has been initiated after reviewers completed their data extraction, but another thorough round of checks is necessary to ensure all possible misinterpretations are corrected.

Finally, the direction of impact extracted, which could be positive, negative or multiple, cannot be studied as an aspect on its own. It always needs to be reported together with: 1) the pressure variable (e.g. amount of litter, fishing intensity), 2) the ecosystem component (e.g. benthos, turtles) and 3) the response variable (e.g. biomass, mortality). Therefore, no general claims can be made on whether a fishery generally had negative or positive impacts, as this fully depends on the context. For example, fishing may display a negative relationship with survival, but a positive one with mortality.

4.5 Description of the database produced

The following figures detail the distribution of retained papers across regions, species, habitats, fisheries, etc.

Case Study and Spatial Representation

Fishing impacts were reported in peer-reviewed literature across all European sea basins (Fig. 4.2). Regions of particular focus were the Mediterranean Sea (n=282, of which 108 inside the SEAwise case study boundaries), the North Sea (n=136, of which 123 inside SEAwise case study boundaries), followed by Western Waters (n=84, of which 73 inside SEAwise case study boundaries) and the Baltic Sea (n=30, of which 16 inside SEAwise case study boundaries). Ten or less than ten studies were located for each of the Black Sea, Norwegian Sea and Barents Sea (Fig. 4.2).

Reflecting the need to address fishing impacts at the scale of an ecosystem, the majority of retained studies (n=326) were done at a large spatial scale, expanding beyond 100 km in reach (Fig. 4.3). Within a study's reach scale, the estimated distance between observations (i.e., resolution) was frequently matching that scale: studies at larger spatial scales also gathered their data with larger distances between observations. However, in some instances the estimated distance between observations was greater than the estimated reach scale of the study (Fig. 4.3).

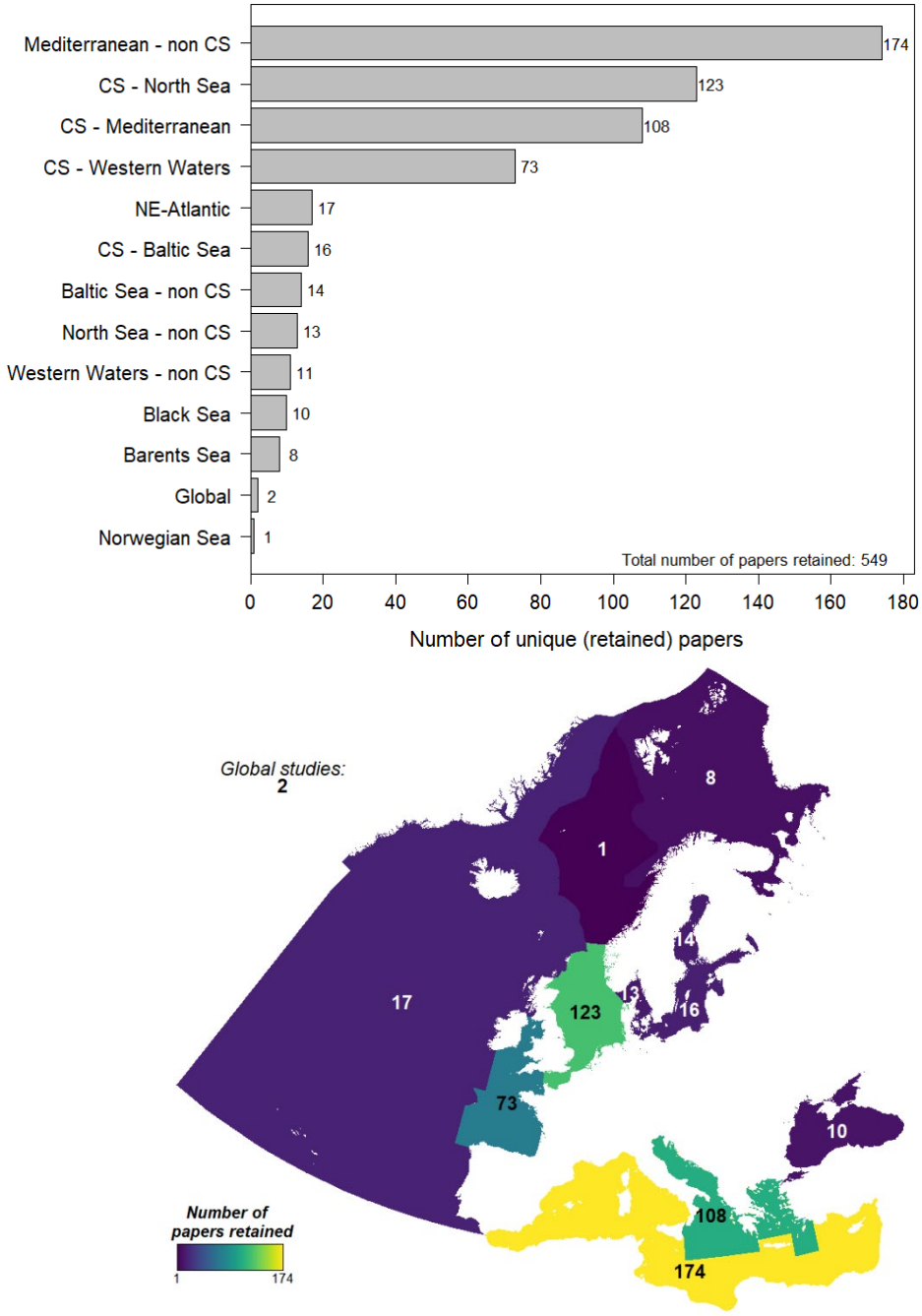


Fig. 4.2 Number of retained studies per European sea basin, including case study (CS) and non-case study (non CS) regions. Papers could span multiple regions, i.e. they are represented more than once.

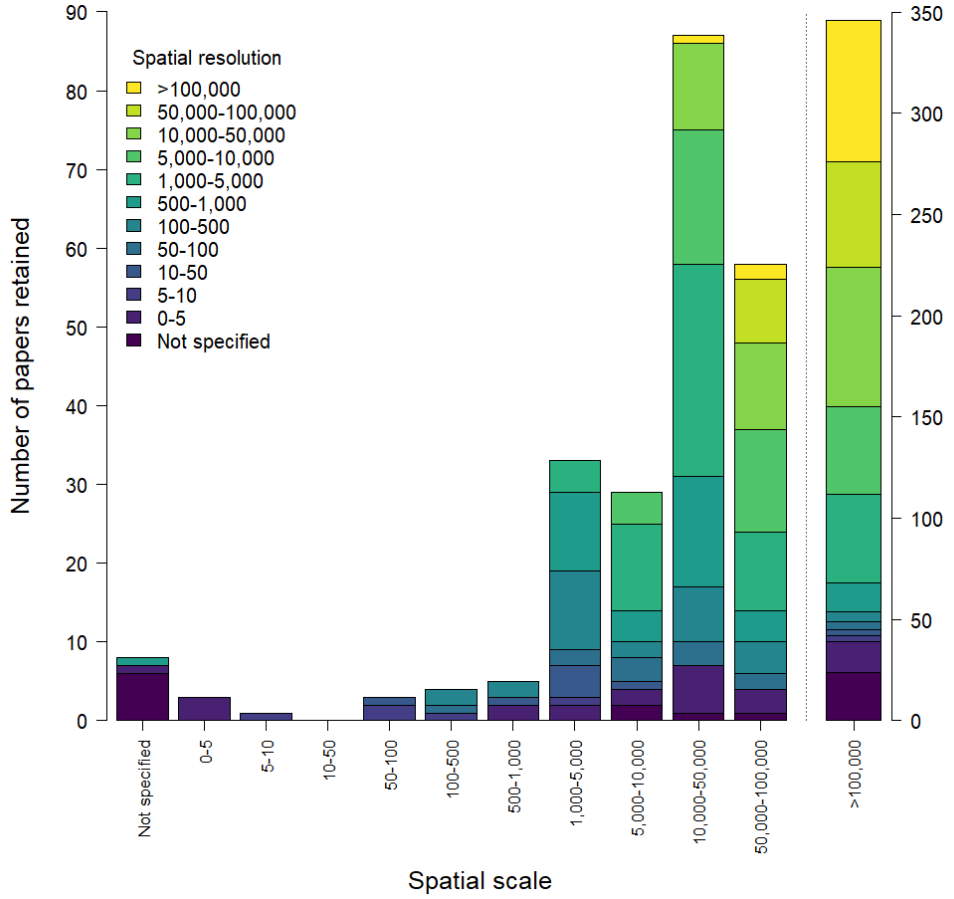


Fig. 4.3 Number of studies per estimated spatial scales (ranging from 0-5 to > 100 000 m). Colours indicate spatial resolution (ranging from 0-5 to > 100 000 m). Note that thescale of the y-axis of the <100 000m column differs from that of the other columns.

Temporal Representation

With an increase in awareness of the need to manage fisheries in a multi-species and –fisheries context by managing trade-offs between different stakeholders and their priorities (Garcia et al. 2003), fishing impact studies increasingly appeared in the published literature since the late 1990s (Fig. 4.4). Regions well known for overexploitation issues, such as the Mediterranean Sea, received particular attention in 2007, 2013 and 2017, possibly as a consequence of outputs created from the 7th and EU Horizon framework research and data collection programmes, or other research activities in the area.

The majority of papers span at least a year or multi-annual periods (Fig. 4.5) to capture more periodic events and reflect upon the seasonality of fishing patterns and migration pathways. The longer fishing impacts were studied in an ecosystem, the greater was also the temporal interval between observations with annual or less frequent observations for multi-decadal studies (Fig. 4.5). As for the spatial scale versus resolution, sometimes the resolution was greater than the scale (Fig. 4.5).

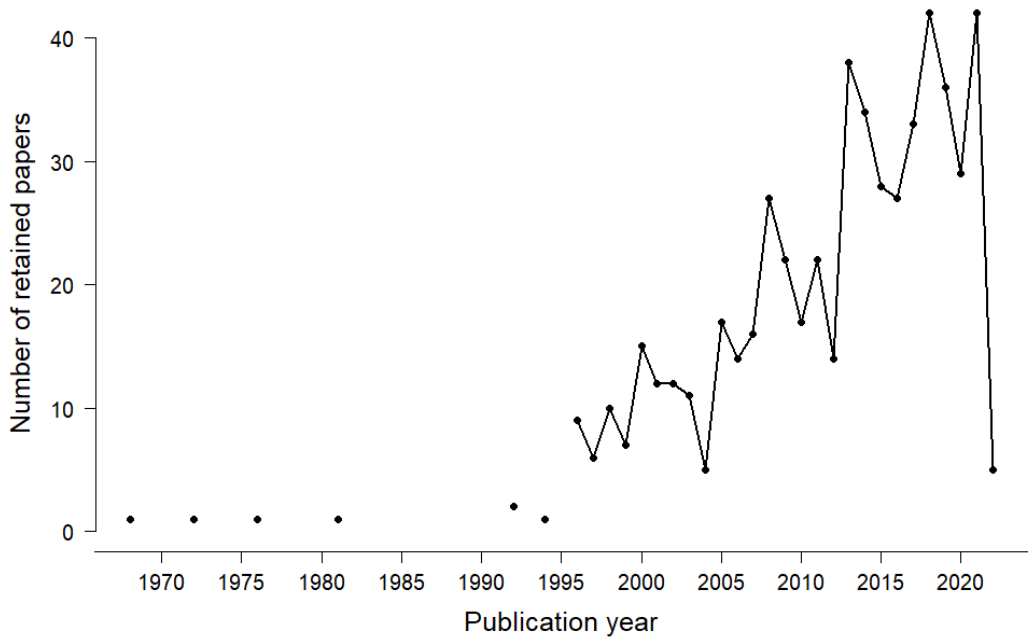


Fig. 4.4 Number of retained papers per year of publication.

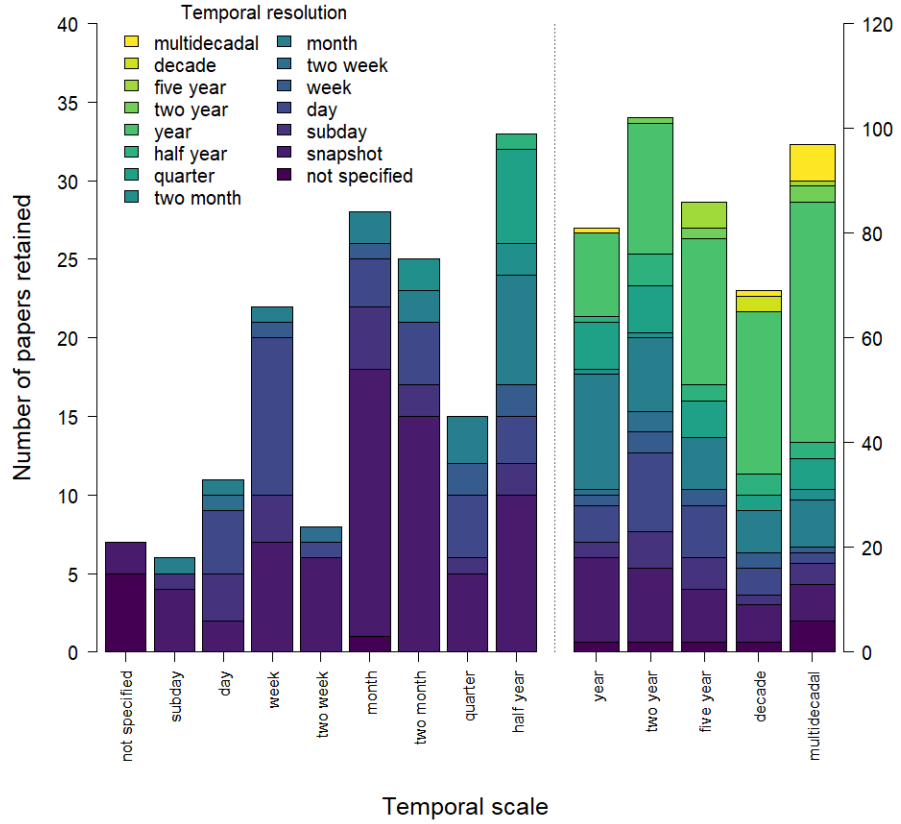


Fig. 4.5 Number of studies per estimated temporal scale (ranging from sub-days till multidecadal periods). Colours indicate temporal resolution (ranging from snapshot to multidecadal). Note that thescale of the y-axis of the <year columns differ from that of the other columns.

Ecosystem components represented in included papers

Ecosystem components of particular interest included benthos and teleost fish (both target and bycatch/non-target species) with 212 and 191 retained studies, respectively (Fig. 4.7). Fishing impacts on reptiles, cephalopods, plants and plankton were least studied. Reptiles were almost exclusively studied in the Mediterranean Sea (Fig. 4.7).

Cartilaginous fish were studied in all Case Study areas, except for the Baltic Sea. For the majority of ecosystem components in Western Waters and in the North Sea, most papers were conducted within the case study boundaries, whereas the opposite was the case for the Mediterranean Sea and the Baltic Sea (Fig. 4.7)

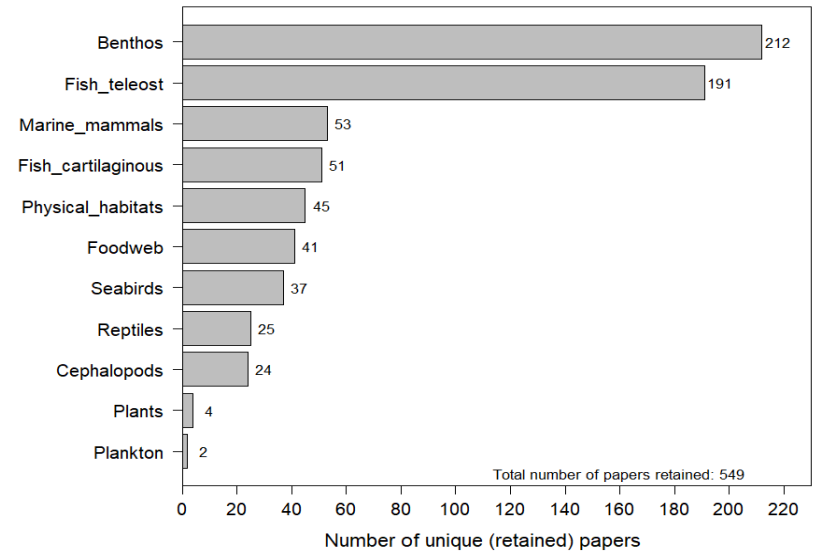
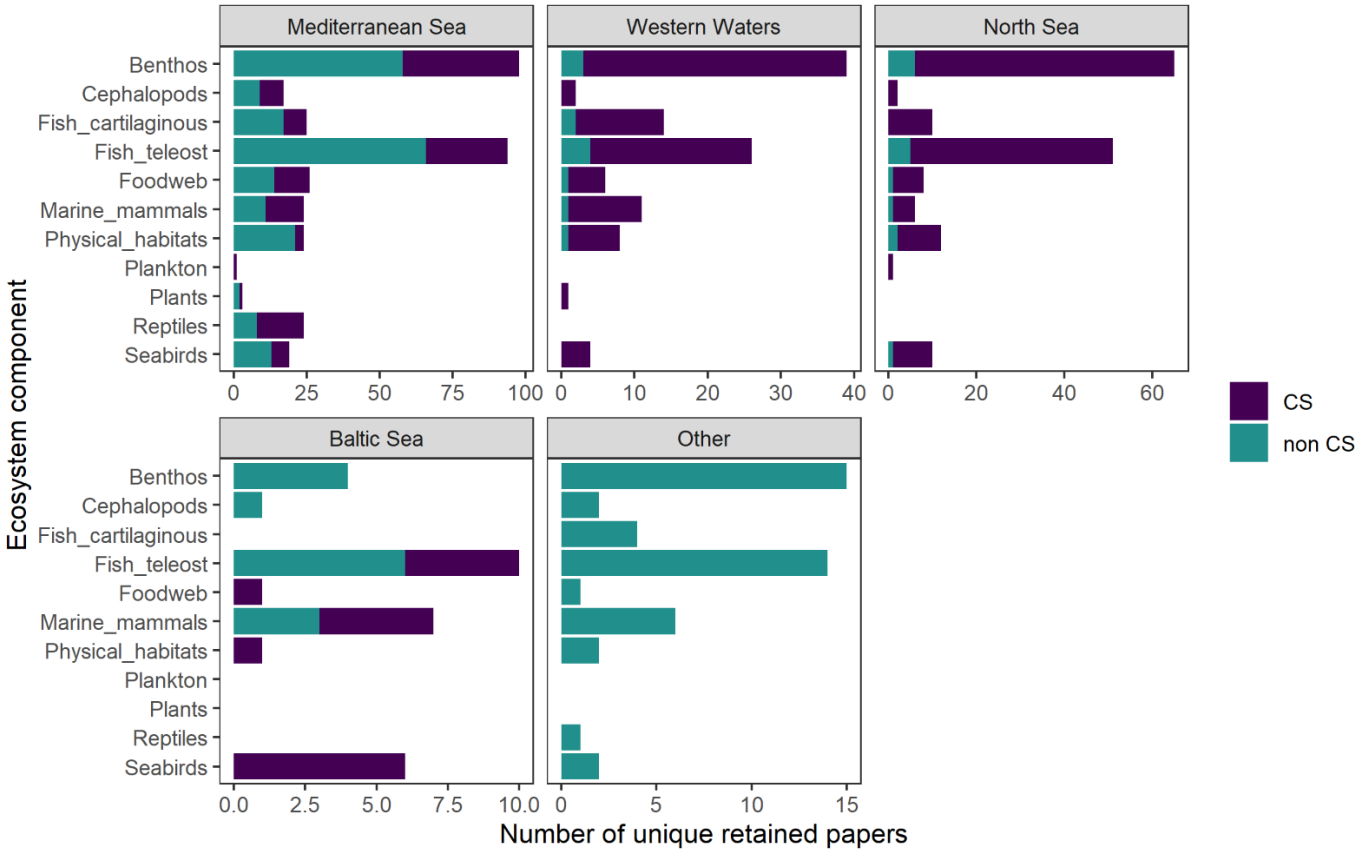


Fig. 4.6 Number of papers by ecosystem component. Papers may have reported on multiple ecosystem components



.Fig. 4.7 Number of papers by ecosystem component, region and case study. All regions outside the case study areas were grouped as 'Other'. Papers may have reported on multiple ecosystem components. Colours indicate inside case study (CS) or outside case study (non CS) boundaries.

Key response variables for the majority of retained papers were abundance, biomass or density metrics, followed by community composition, mortality and 'other' (Fig. 4.8). Reported response variables in the latter category often

involved metrics related to the non-living part of the sediment or seafloor. Variables associated to physiology, growth and reproduction were studied the least.

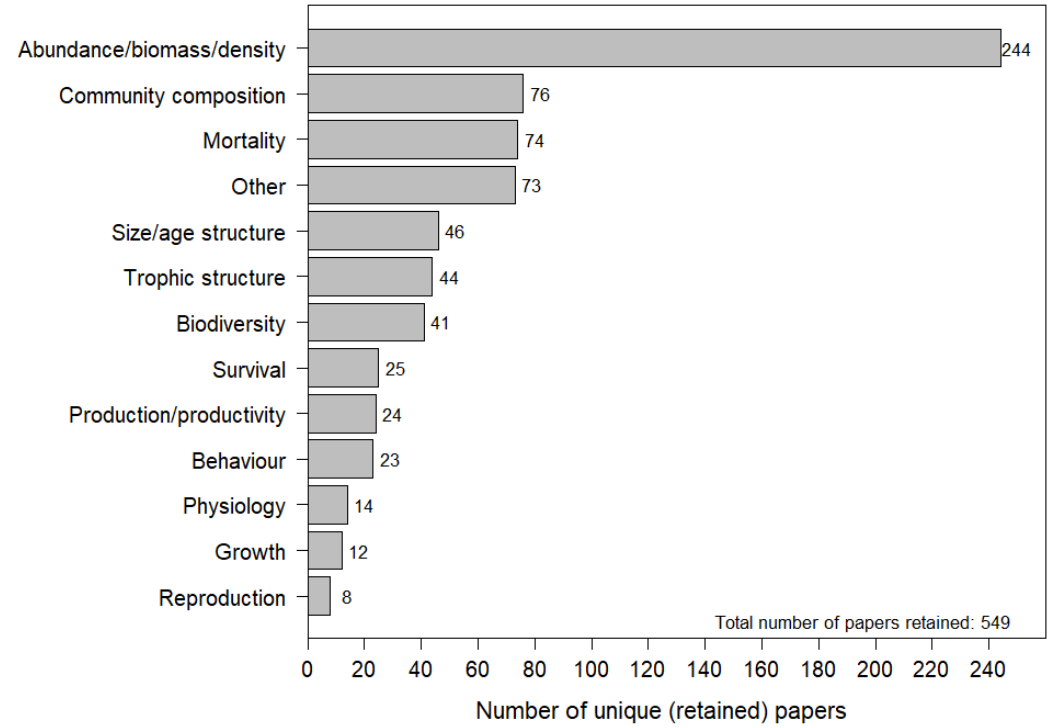


Fig. 4.8 Studied response variables of interest in retained papers. Papers may have reported on multiple response variables.

Across the different kinds of pressure types, fishing impacts from catch and bycatch was the most frequently studied pressure for all ecosystem components, except for benthos and physical habitats for which physical disturbance of the seafloor was most frequently studied (Fig. 4.9). The impact of discarding, i.e. the input of organic matter in the form of discarded catch, was studied particularly for seabirds, whereas effects of input of litter was most frequently studied for benthos. Effects of underwater noise related to fishing activities were studied for marine mammals and seabirds. Electromagnetic input and visual disturbance impacts were rarely studied and only for a narrow number of taxa (i.e., teleost fish and some benthic species).

Commercial fishing impacts were by far most explored compared to recreational or other types of fisheries, particularly impacts on benthic organisms and fish species (Fig. 4.10). In terms of commercial fishing gear, most papers reported on fishing impacts from demersal trawls (Fig. 4.11). Most papers on recreational fisheries studied the impact on fish (Fig. 4.10) by hooks and lines (i.e., angling; Fig. 4.11). In very few cases the impact of a scientific gear rather than a commercial or recreational gear was explicitly studied (Fig. 4.11).

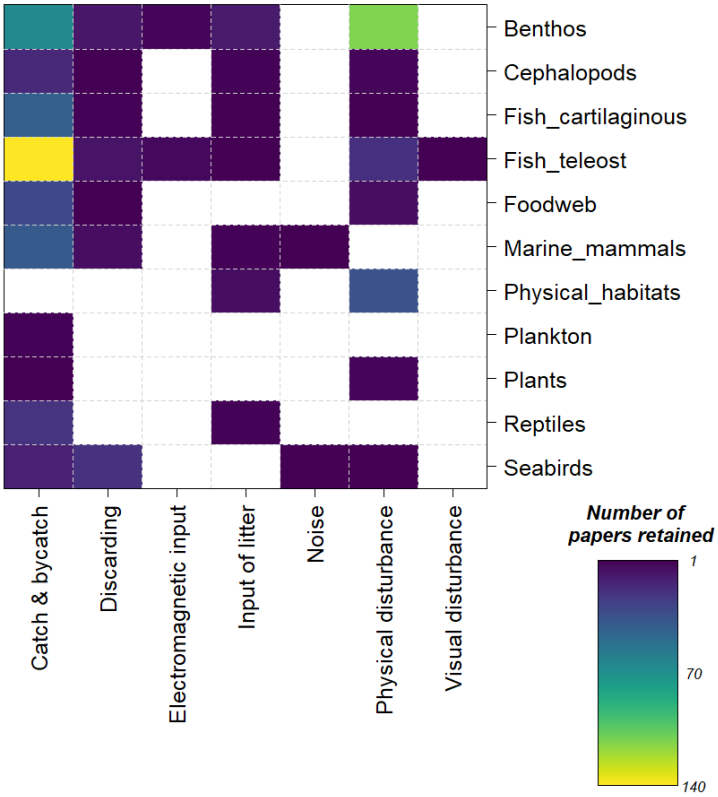


Fig. 4.9 Number of times retained papers studied the impact of a pressure type (horizontal axis) on an ecosystem component (vertical axis). Papers may have reported on multiple pressure types.

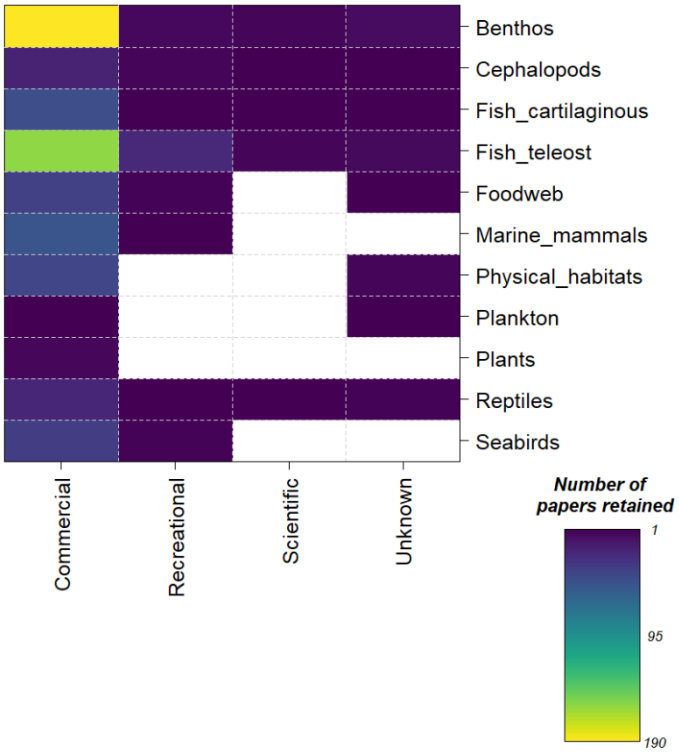


Fig. 4.10 Number of times retained papers studied the impact of a fishery type (horizontal axis) on an ecosystem component (vertical axis). Papers may have reported on multiple fishery types.

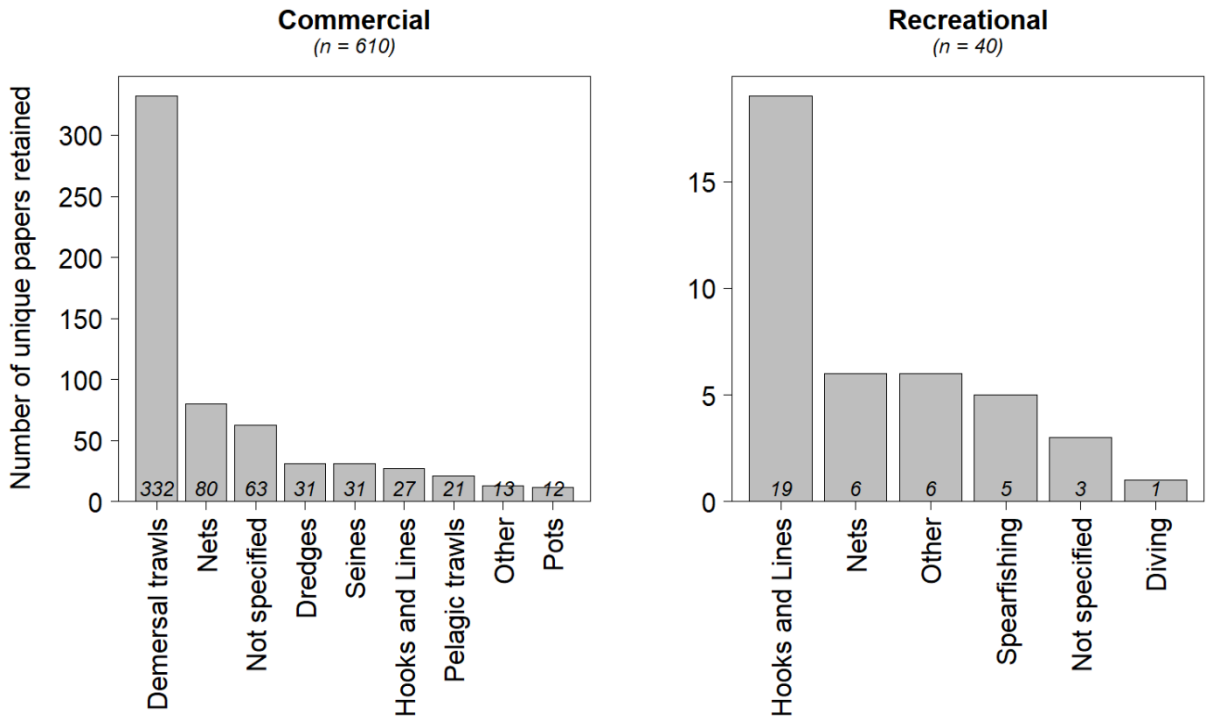


Fig. 4.11 Number of times retained papers studied a fishing gear for commercial (left) and recreational (right) fisheries.

Quality of studies

Spatial

83% of the studies were deemed to have a sufficient spatial coverage and resolution supporting the claims being made. For 12% of the studies, the spatial scale was larger than the claims being made and the spatial resolution was sufficient, or the resolution was finer than processes being described and claims are not generalised greater than the spatial scale. For 5% of the studies, the claims being made were extended beyond the spatial scale of sampling, or the spatial resolution was not sufficient to capture proposed processes. Quality scoring was similar across case studies and regions (Fig. 4.12).

Temporal

81% of the studies were deemed to have a temporal scale and resolution that are sufficient to support the claims being made and/or sampling resolution is on the scale of the claims. For 12% of the studies, time series extended beyond the trends being described in at least one direction and the temporal resolution was finer than processes being described. For 7% of the studies, claims were extended far beyond the temporal scale of sampling, or the temporal resolution was not sufficient to capture proposed processes. Quality scoring was similar across case studies and regions (Fig. 4.13).

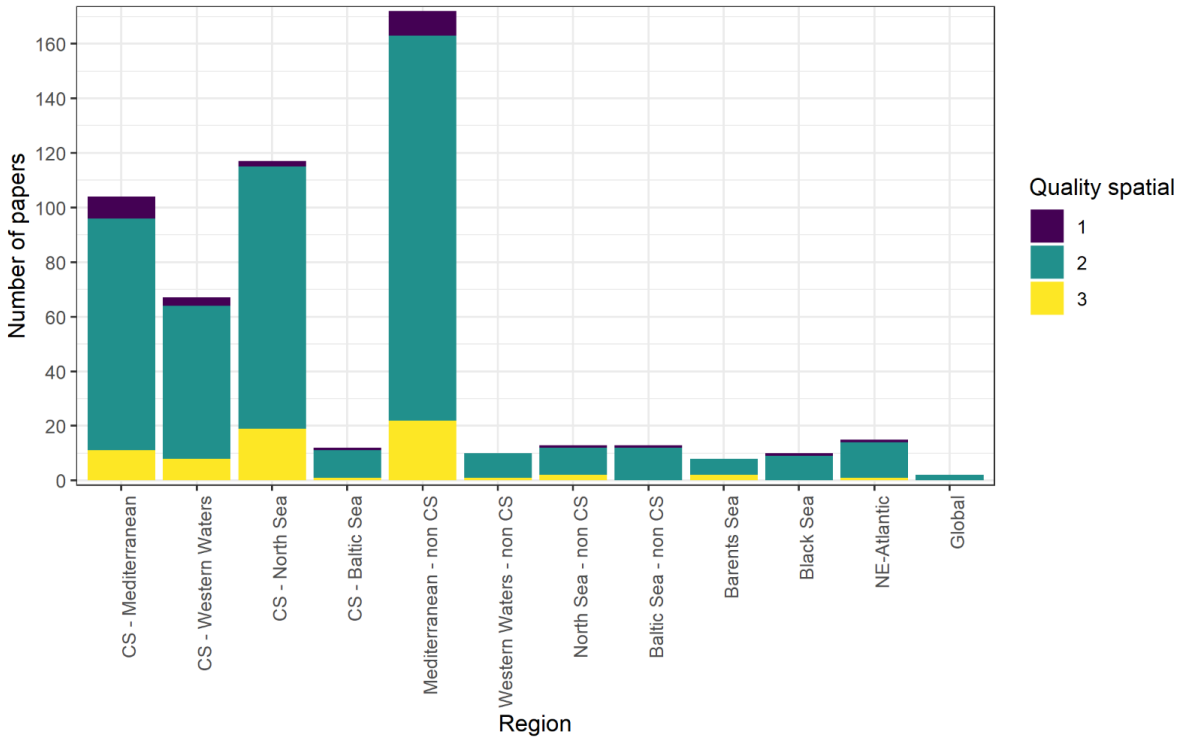


Fig. 4.12 Number of retained papers by region and spatial quality scores. 1 = scale too large or resolution too fine, 2 = scale and resolution sufficient, 3 = claims beyond scale or resolution not sufficient.

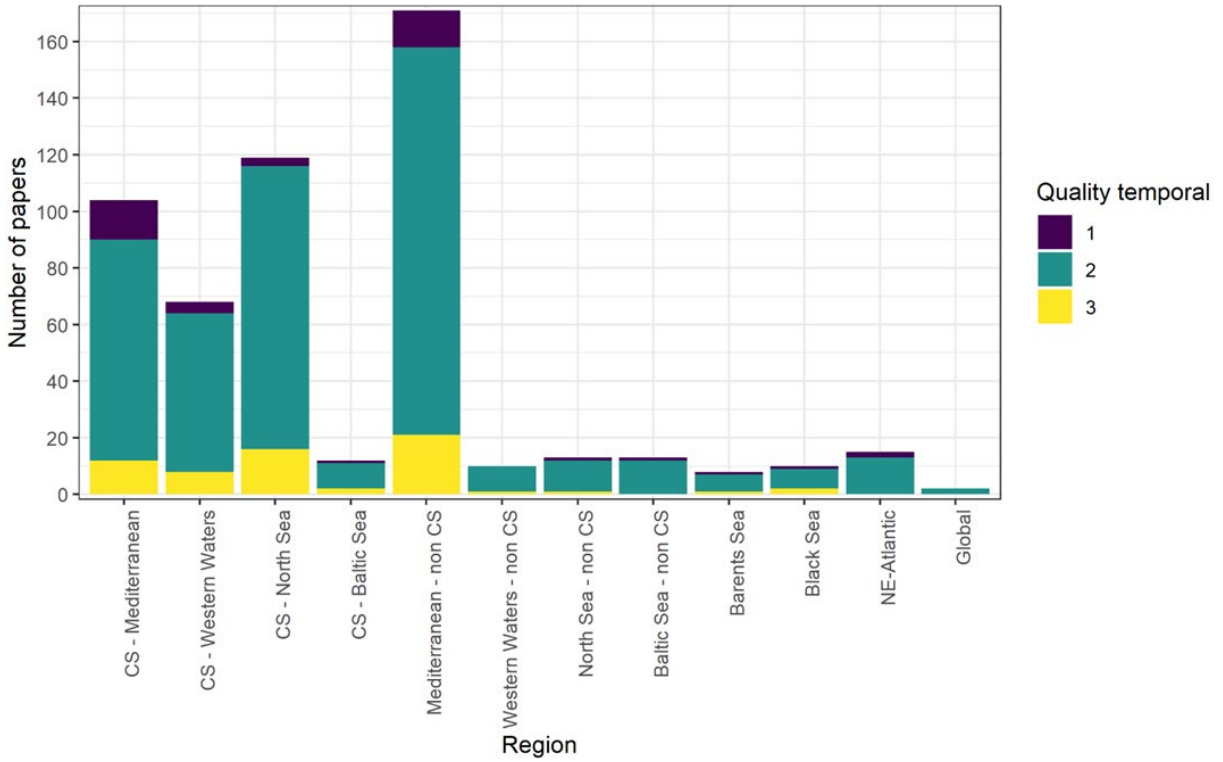


Fig. 4.13 Number of retained papers by region and temporal quality scores. 1 = claims are beyond scale or resolution is not sufficient, 2 = scale and resolution sufficient, 3 = scale too large or resolution too fine.

Methods

74% of the studies were deemed to have applied methods that were suitable for the data and output was interpreted correctly. For 20% of the studies, reviewers had doubts about the suitability of the methods. For 6% of the studies, the methods applied were clearly not suitable for the data, or the claims being made were not supported by results. Quality scoring was similar across case studies and regions (Fig. 4.14).

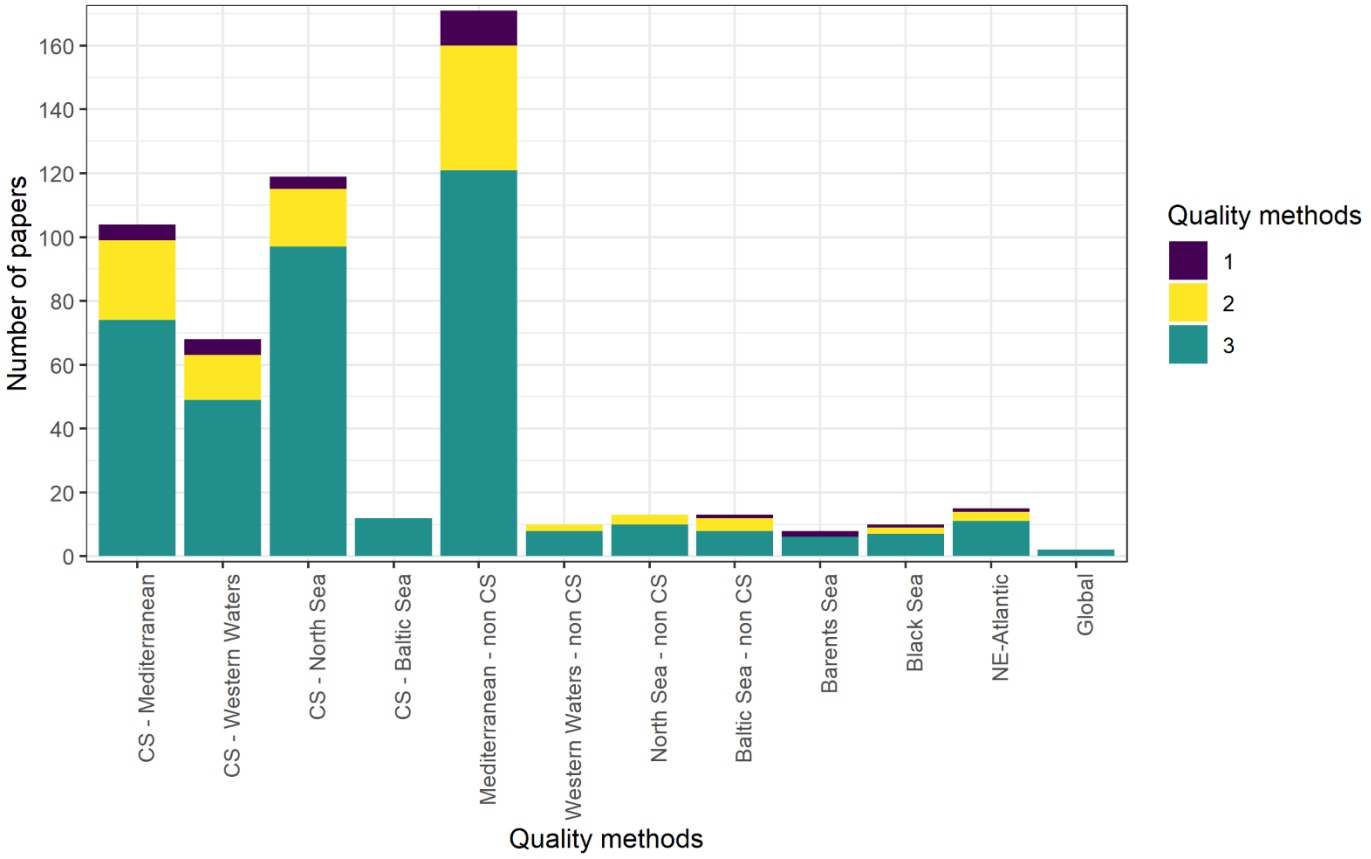


Fig. 4.14 Number of retained papers by region and method quality scores. 1 = not suitable or results do not support claims, 2 = suitability doubtful, 3 = suitable.

4.6 Subject coverage

Task 4.2: Bycatch of Protected, Endangered and Threatened species

Of the papers categorized as dealing with catch and bycatch as pressure type, the majority investigated impacts on teleost fish, followed by benthos, cartilaginous fish, marine mammals and food webs (Fig. 4.15). For teleost fish, cephalopods and food webs, most papers dealt with target species, whereas the majority of papers studying the impacts on cartilaginous fish, marine mammals, reptiles and seabirds dealt with bycatch of species.

In total, 114 papers were labelled as Task 4.2, and an additional 5 papers studied bycatch. Results below are based on these 119 papers, from here on referred to as “Task 4.2 papers”.

Of the species listed as Protected, Endangered and Threatened according to the Commission Implementing Decision (EU) 2016/1251, 48 species were reported in Task 4.2 papers (Table 4.5). The reported PET species include cartilaginous and teleost fish, marine mammals, reptiles and seabirds.

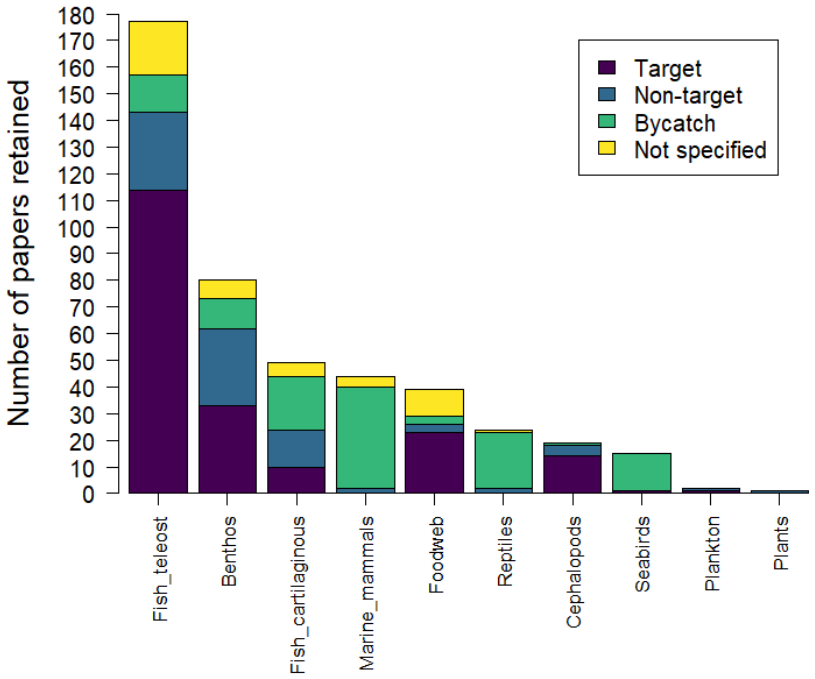


Fig. 4.15 Number of retained papers by ecosystem component for which the identified pressure was 'Catch and bycatch'. Colours indicate further specification of the catch.

Table 4.5 List of PET species by region and ecosystem component reported on in terms of fishing impacts by Task 4.2 papers in the review.

Ecosystem component	PET species	Region
Fish_cartilaginous	*Dasyatis pastinaca*	CS - Mediterranean
	Etmopterus spinax	Mediterranean - non CS
	Galeorhinus galeus	NE-Atlantic
	Galeus melastomus	CS - Western Waters, Mediterranean - non CS
	Lamna nasus	CS - Western Waters
	Mustelus asterias	Mediterranean - non CS, NE-Atlantic
	Mustelus mustelus	Mediterranean - non CS
	Raja clavata	Black Sea, CS - Mediterranean, CS - North Sea, CS - Western Waters, Mediterranean - non CS
	Raja montagui	CS - Western Waters
	Scyliorhinus canicula	CS - Western Waters, Mediterranean - non CS, NE-Atlantic
	Squalus acanthias	Black Sea, CS - North Sea, CS - Western Waters, NE-Atlantic
	Torpedo marmorata	CS - Mediterranean, Mediterranean - non CS
Fish_teleost	*Anarhichas lupus*	CS - North Sea
	Coregonus albula	Baltic Sea - non CS
	Dicentrarchus labrax	Mediterranean - non CS
	Diplodus annularis	CS - Mediterranean
	Gadus morhua	CS - Baltic Sea, CS - North Sea, CS - Western Waters, North Sea - non CS
	Lepidopus caudatus	Mediterranean - non CS

Ecosystem component	PET species	Region
	Merlangius merlangus	CS - North Sea
	Molva molva	CS - Western Waters
	Mora moro	Mediterranean - non CS
	Pagellus acarne	CS - Mediterranean
	Pagellus bogaraveo	CS - Western Waters
	Pollachius pollachius	North Sea - non CS
	Pomatomus saltatrix	Mediterranean - non CS
Marine_mammals	*Delphinus delphis*	Black Sea, CS - Mediterranean, CS - Western Waters, Mediterranean - non CS, Western Waters - non CS
	Globicephala melas	CS - Western Waters
	Grampus griseus	CS - Mediterranean
	Halichoerus grypus	CS - Baltic Sea, CS - Western Waters
	Monachus monachus	CS - Mediterranean
	Orcinus orca	Mediterranean - non CS
	Phoca vitulina	CS - Baltic Sea
	Phocoena phocoena	Baltic Sea - non CS, Black Sea, CS - Baltic Sea, CS - Mediterranean, CS - North Sea, CS - Western Waters, North Sea - non CS
	Stenella coeruleoalba	CS - Mediterranean, CS - Western Waters, Mediterranean - non CS
	Tursiops truncatus	CS - Mediterranean, Mediterranean - non CS
Reptiles	*Caretta caretta*	CS - Mediterranean, Mediterranean - non CS
	Chelonia mydas	CS - Mediterranean, Mediterranean - non CS
	Dermochelys coriacea	CS - Mediterranean
Seabirds	*Aythya marila*	CS - Baltic Sea
	Calonectris diomedea	CS - Mediterranean, Mediterranean - non CS
	Cepphus grylle	Barents Sea
	Clangula hyemalis	CS - Baltic Sea
	Fulmarus glacialis	Barents Sea
	Larus audouinii	CS - Mediterranean, Mediterranean - non CS
	Larus fuscus	CS - North Sea
	Melanitta fusca	CS - Baltic Sea
	Phalacrocorax carbo	CS - Baltic Sea
	Puffinus yelkouan	CS - Mediterranean

When including both PET and non-PET species, the majority of Task 4.2 papers investigated fish, marine mammals, reptiles and seabirds. PET interactions and bycatch were prominent for the Mediterranean (Fig. 4.16). Reptiles (i.e. sea turtles) were almost exclusively studied in the Mediterranean Sea.

Bycatch impacts were quantified by measuring changes to abundance, biomass, or density of ecosystem components, or by quantifying mortality/survival (Fig. 4.17).

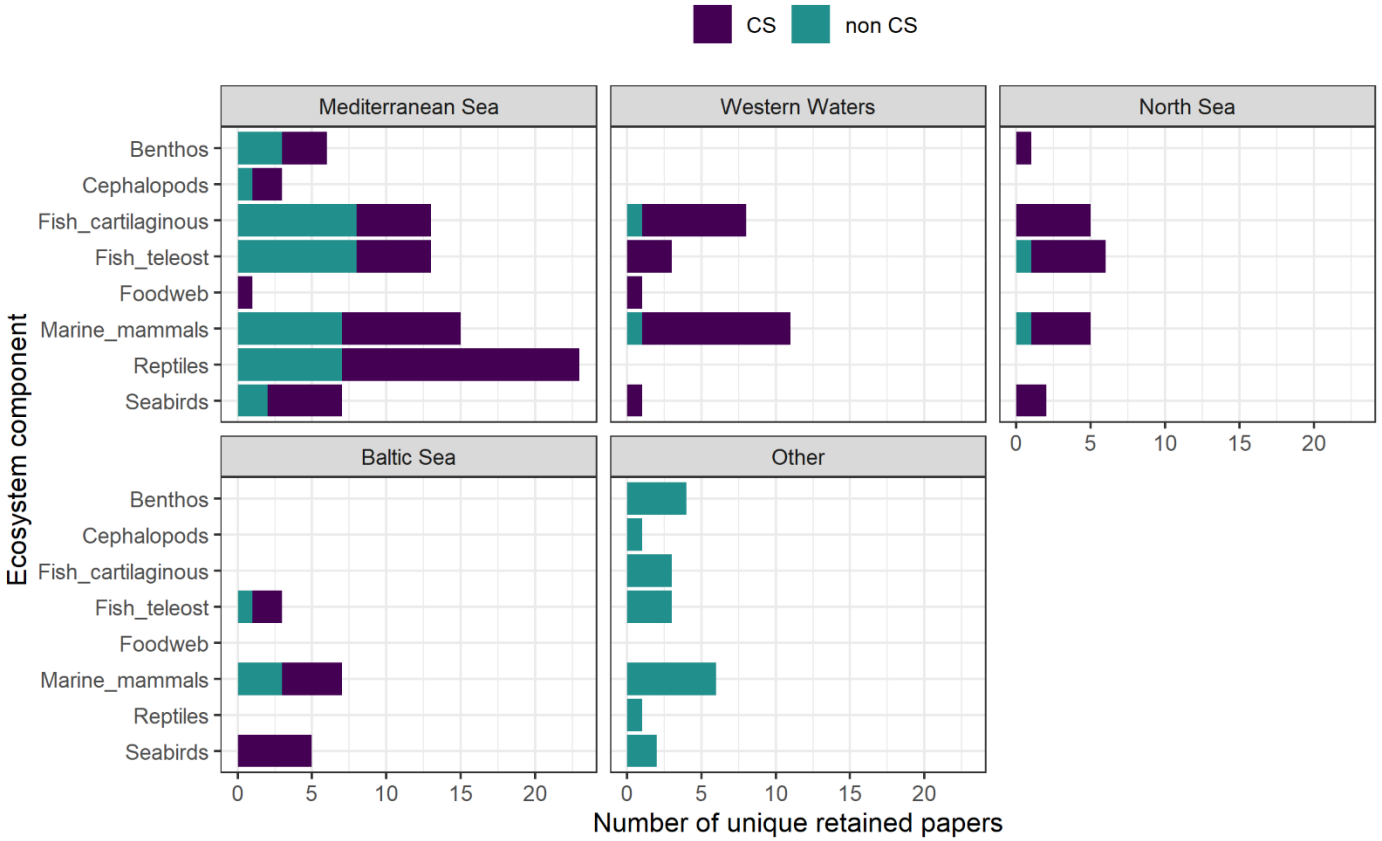


Fig. 4.16 Number of papers by ecosystem component, region and case study for Task 4.2. All regions outside the case study areas were grouped as 'Other'. Papers may have reported on multiple ecosystem components. Colours indicate inside case study (CS) or outside case study (non CS) boundaries.

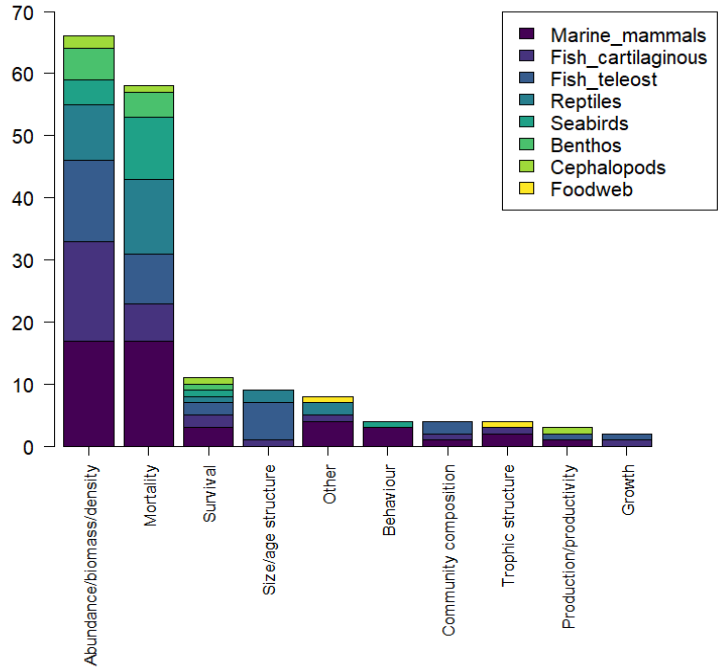


Fig. 4.17 Number of times Task 4.2 papers reported response variables by ecosystem component. Papers may have reported on multiple response variables.

Task 4.3: Benthic habitats

In total, 172 papers were labelled as Task 4.3. Additionally, 31 papers were labelled otherwise, but studied the Pressure type "Physical disturbance of the seafloor". Results below are based on these 203 papers, and are from here on referred to as "Task 4.3 papers". Benthos, physical habitats and fish were the most prominent ecosystem components of benthic impact studies (Fig. 4.18). These impacts were studied in all case study areas, but to a lesser extent in the Baltic Sea (Fig. 4.19). Of papers studying benthic epifauna and for which a further classification was made into corals, sea pens and sponges, corals were most often studied (Fig. 4.18). Yet, many papers studied benthic communities in general, so these numbers may not fully represent the number of papers on these benthic epifaunal groups in the entire data base.

The vast majority of Task 4.3 papers investigated the impact of physical disturbance to the seafloor on benthic habitats (Fig. 4.20). Several papers also studied the effect of catch and bycatch on several ecosystem components, whereas few papers studied the impact of discarding, electromagnetism and litter on benthos.

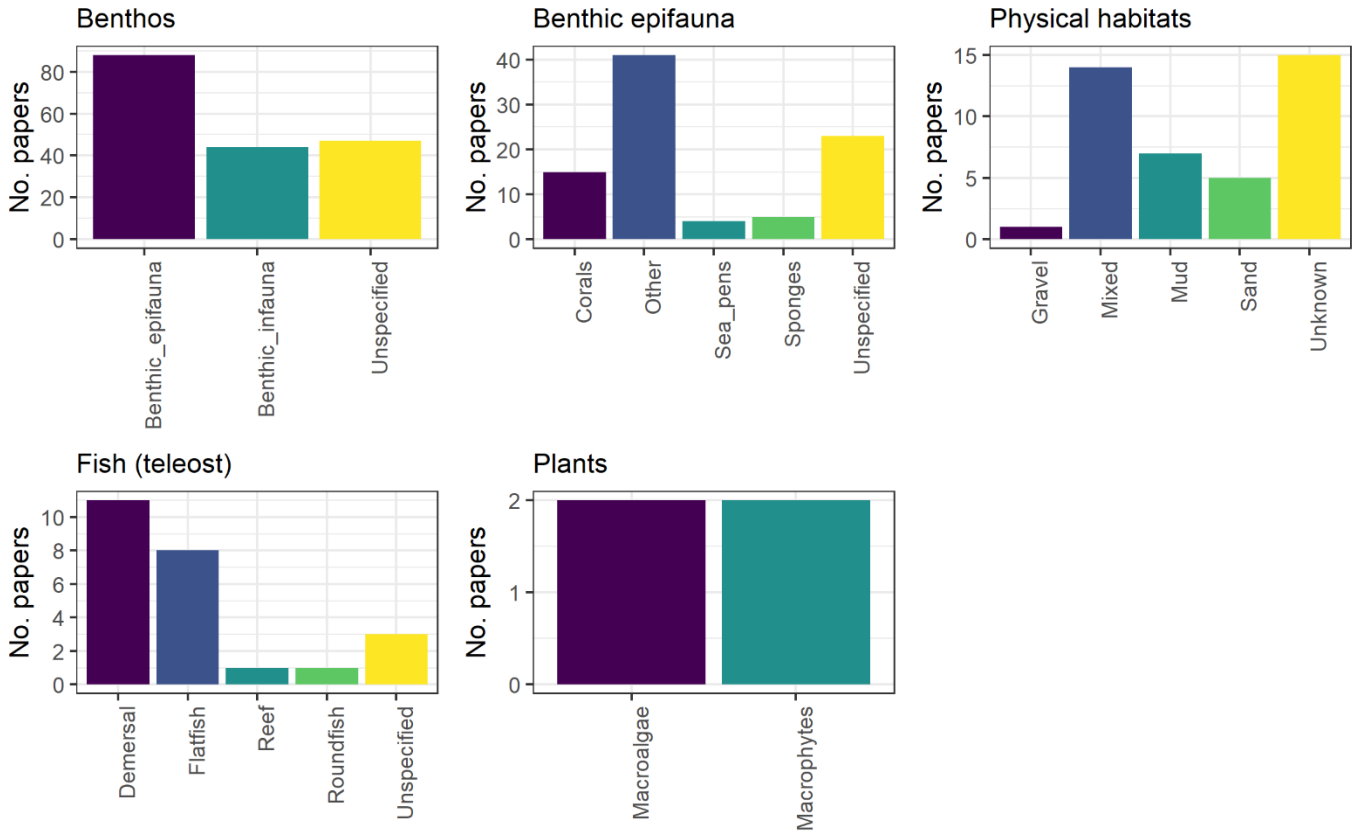


Fig. 4.18 Benthic habitat components and associated ecosystem components and species assemblages affected by physical disturbance from fishing activities, as reported in Task 4.3 papers.

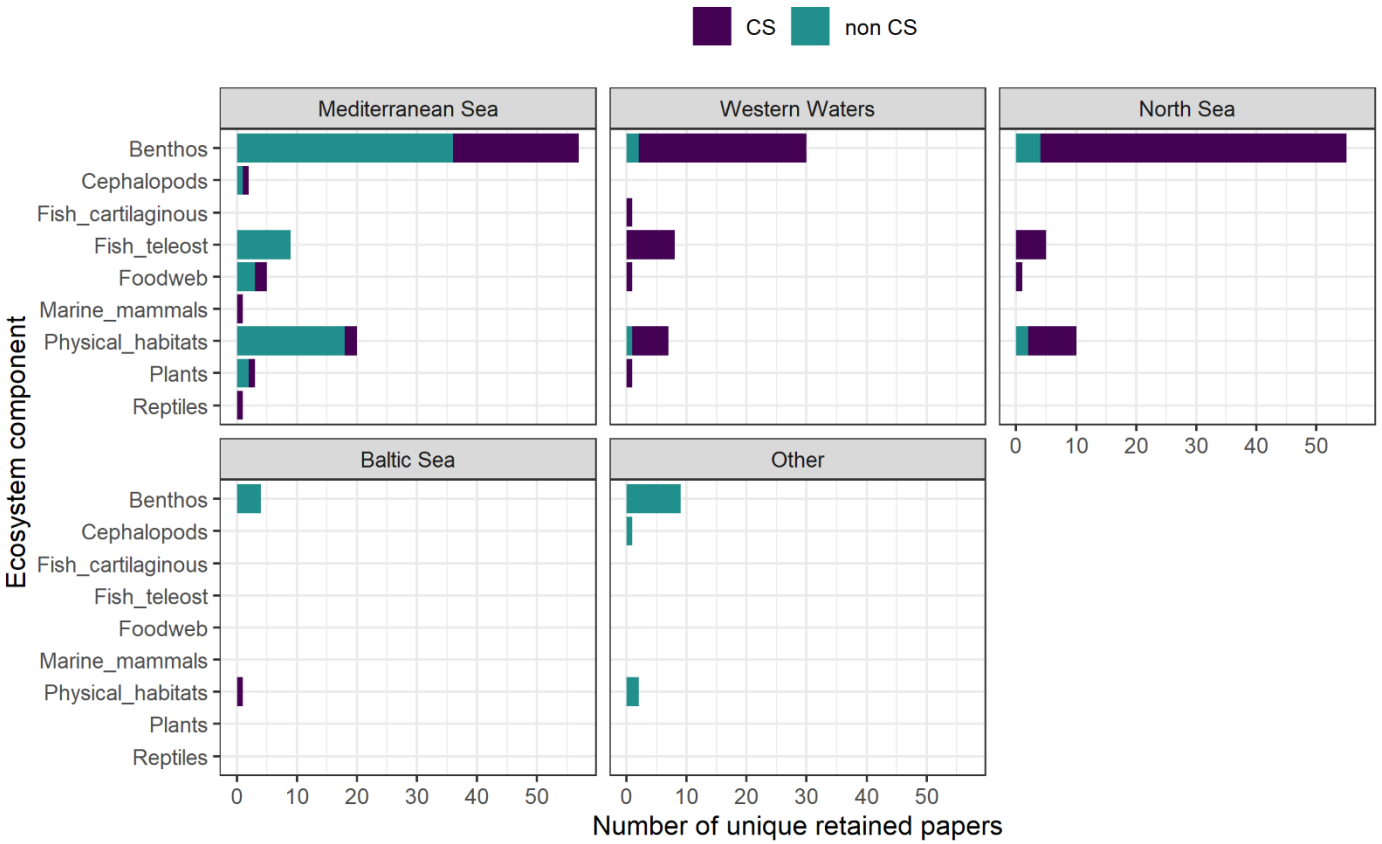


Fig. 4.19 Number of papers by ecosystem component, region and case study for Task 4.3. All regions outside the case study areas were grouped as 'Other'. Papers may have reported on multiple ecosystem components. Colours indicate inside case study (CS) or outside case study (non CS) boundaries.

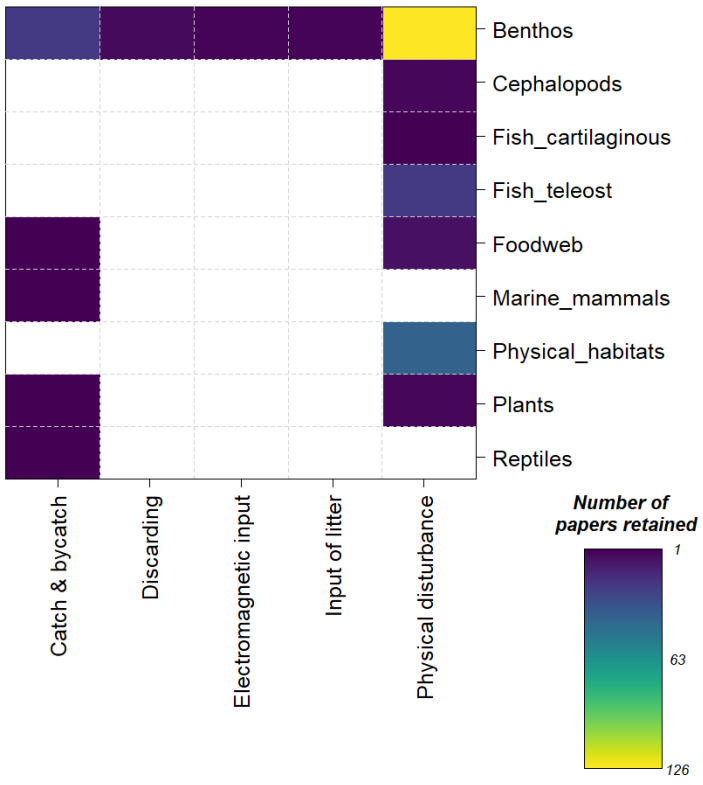


Fig. 4.20 Number of times Task 4.3 papers studied the impact of a pressure type (horizontal axis) on an ecosystem component (vertical axis). Papers may have reported on multiple pressure types.

Fishing impacts on benthic habitats were mostly quantified by measuring changes to the abundance, biomass, or density of their biological communities, followed by community composition, biodiversity and 'other' variables – often related to non-living parts of the sediment or seafloor (Fig. 4.21).

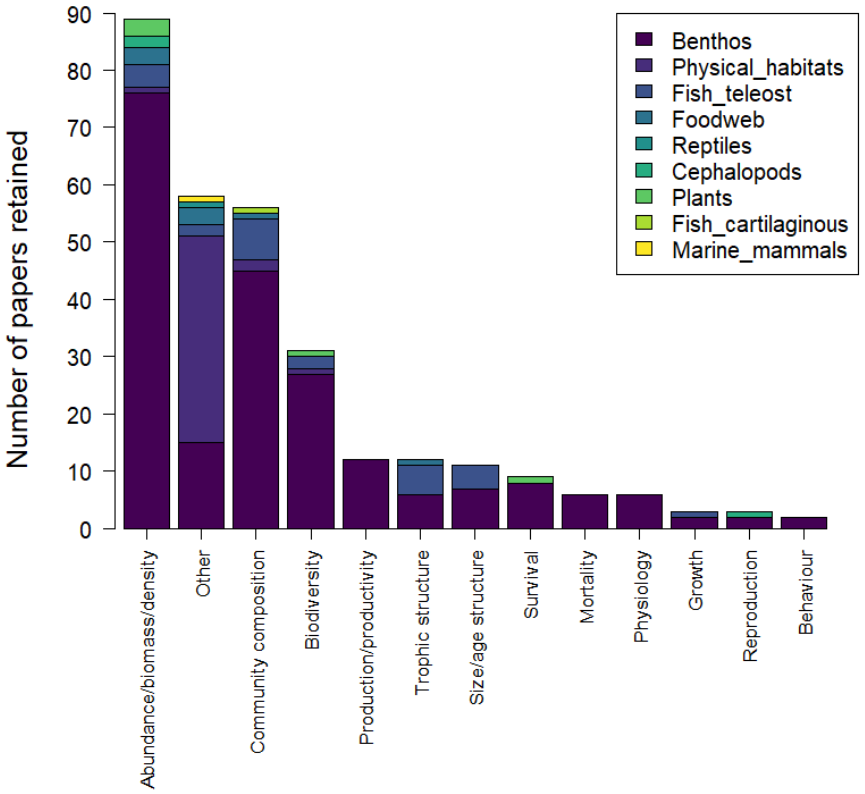


Fig. 4.21 Number of times Task 4.3 papers reported response variables by ecosystem component. Papers may have reported on multiple response variables.

Task 4.4: Food webs and biodiversity

In total, 173 papers were labelled as Task 4.4. Additionally, 63 papers were labelled otherwise, but studied "Trophic structure", "Biodiversity" or "Community composition" as response variable. One paper was not labelled as Task 4.4 but included the ecosystem component "food web". Combined, these 237 papers are from here on referred to as "Task 4.4 papers" and are further analysed below.

Teleost fish and benthos were the most studied ecosystem components in Task 4.4. papers, followed by food webs in general and cartilaginous fish (Fig. 4.22). Impacts were studied in all areas, though only a handful of Task 4.4 papers were reported for the Baltic Sea.

The majority of Task 4.4 papers investigated the impact of catch and bycatch on food webs or biodiversity, followed by the effects of discarding and physical disturbance of the seafloor (Fig. 4.23). Papers on discarding particularly studied its impact on seabirds. A few Task 4.4 papers studied the impact of litter on benthos, the impact of noise on marine mammals, and the impact of visual disturbance on teleost fish (use of artificial light to attract fish).

Fishing impacts on food webs and biodiversity were mostly quantified by measuring changes to abundance, biomass, or density of ecosystem components, followed by community composition, trophic structure, biodiversity and size/age structure (Fig. 4.24).

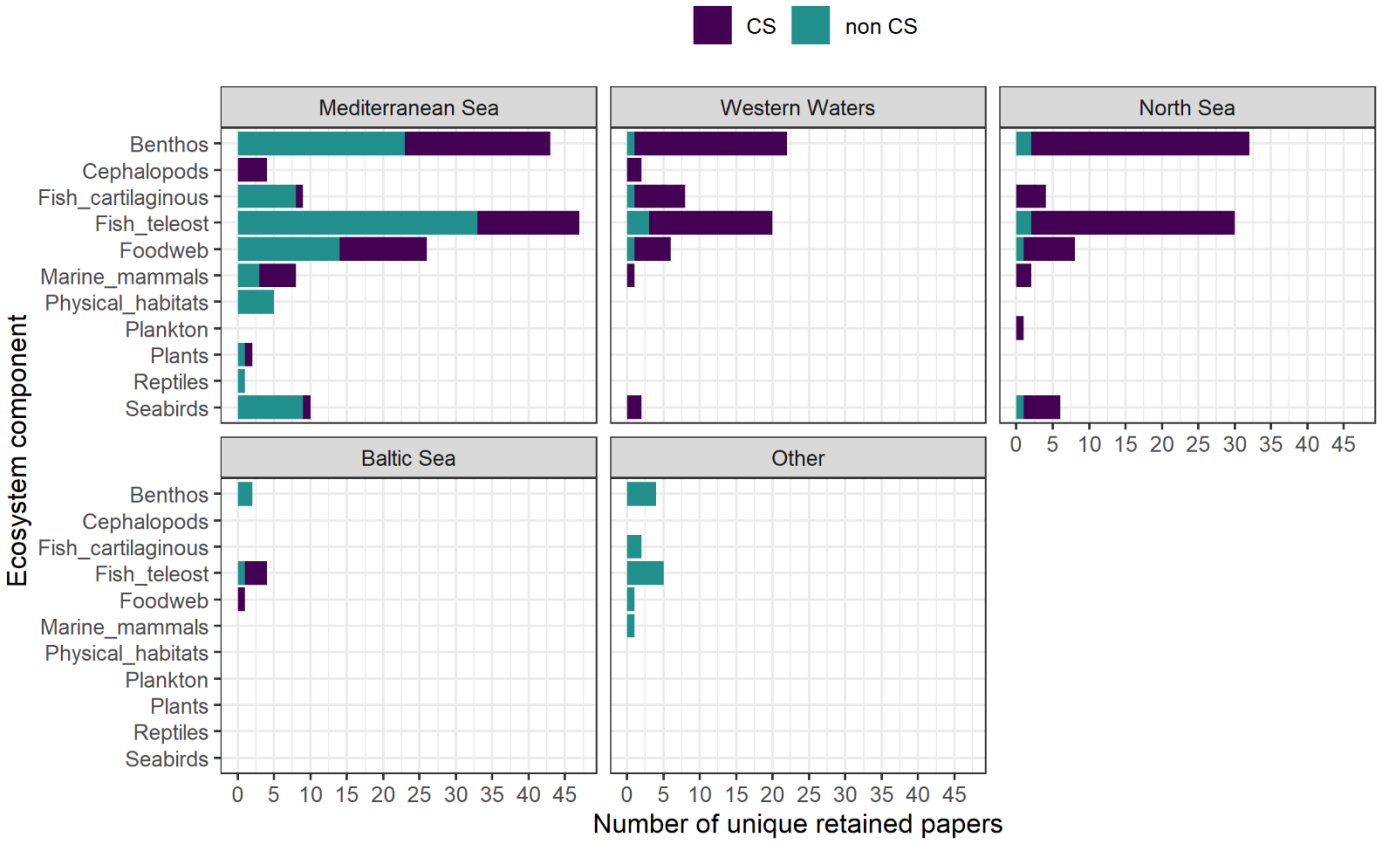


Fig. 4.22 Number of papers by ecosystem component, region and case study for Task 4.4. All regions outside the case study areas were grouped as 'Other'. Papers may have reported on multiple ecosystem components. Colours indicate inside case study (CS) or outside case study (non CS) boundaries.

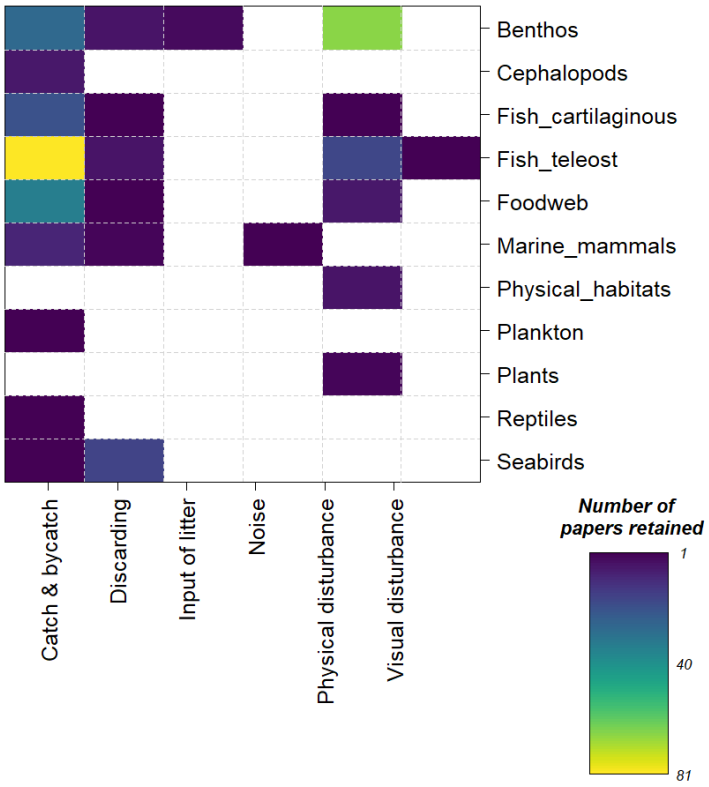


Fig. 4.23 Number of times Task 4.4 papers studied the impact of a pressure type (horizontal axis) on an ecosystem component (vertical axis). Papers may have reported on multiple pressure types.

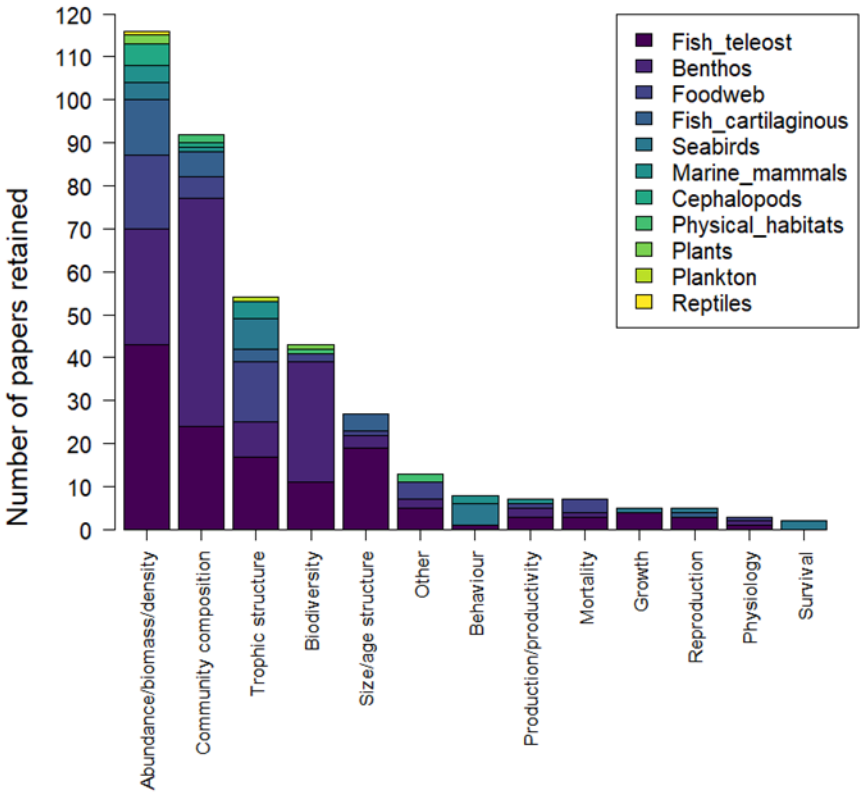


Fig. 4.24 Number of times Task 4.4 papers reported response variables by ecosystem component. Papers may have reported on multiple response variables.

Task 4.5: Litter

In total, 28 papers were labelled as Task 4.5. Additionally, 2 papers studied the impact of litter on the ecosystem. Combined, these 30 papers are from here on referred to as "Task 4.5 papers" and further analysed below.

The majority of papers studied the impact of litter in the Mediterranean Sea, while just a few papers studied litter impacts Western Waters and the North Sea. No papers on this topic were found in this review on the Baltic Sea (Fig.

4.25). Impacts on benthos and physical habitats were most often studied (

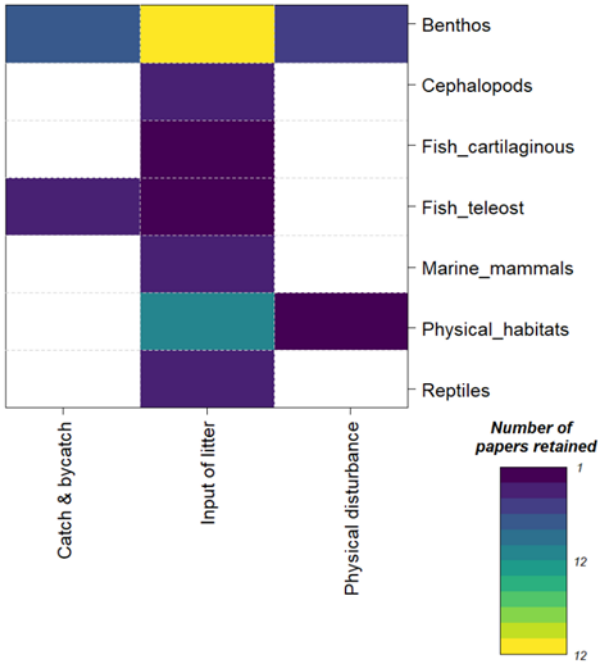


Fig. 4.26). A variety of species and taxa was studied, as listed in (Table 4.6). Note that this list was generated based on what reviewers reported beyond the taxonomic level of ecosystem components only. Therefore, it is does not represent the full breadth of ecosystem components studied.

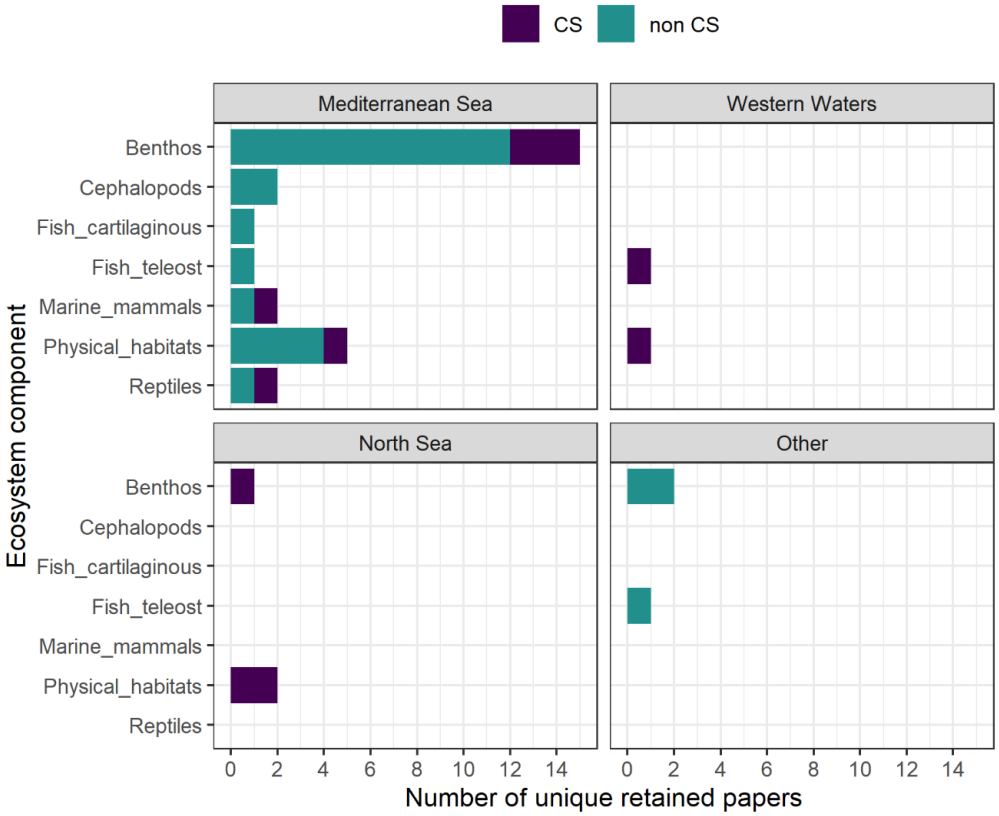


Fig. 4.25 Number of papers by ecosystem component, region and case study for Task 4.5. All regions outside the case study areas were grouped as 'Other'. Papers may have reported on multiple ecosystem components. Colours indicate inside case study (CS) or outside case study (non CS) boundaries.

Table 4.6 List of taxa by region and ecosystem component reported by Task 4.5 papers in the review on impacts from fisheries-related litter.

Ecosystem component	Taxon	Region
Benthos	Anthozoa	CS - Mediterranean
	Asterias rubens	NE-Atlantic
	Bivalvia	CS - Mediterranean, Mediterranean - non CS
	Bryozoa	Mediterranean - non CS
	Calcarea	CS - Mediterranean
	Cancer pagurus	NE-Atlantic
	Carcinus maenas	NE-Atlantic
	Chionoecetes opilio	Barents Sea
	Cnidaria	Mediterranean - non CS
	Corallium rubrum	Mediterranean - non CS
	Crustacea	Mediterranean - non CS
	Dendrophyllia cronigera	Mediterranean - non CS
	Echinodermata	Mediterranean - non CS
	Eunicella cavolinii	Mediterranean - non CS
	Fouling epifauna on litter	Mediterranean - non CS
	Gastropoda	CS - Mediterranean
	Globothalamea	CS - Mediterranean
	Gorgonian	Mediterranean - non CS
	Gymnolaemata	CS - Mediterranean
	Hexanauplia	CS - Mediterranean
	Hydrozoa	CS - Mediterranean, Mediterranean - non CS
	Liocarcinus depurator	NE-Atlantic
	Lophelia pertusa	CS - Mediterranean, Mediterranean - non CS
	Madrepora oculata	CS - Mediterranean, Mediterranean - non CS
	Mollusca	Black Sea
	Nephrops novegicus	NE-Atlantic
	Polychaeta	CS - Mediterranean, Mediterranean - non CS
	Porifera	Mediterranean - non CS
	Scleractinian	Mediterranean - non CS
	Sponges	Mediterranean - non CS
	Stenolaemata	CS - Mediterranean
Cephalopods	*Octopus vulgaris*	Mediterranean - non CS
Fish_cartilaginous	*Raja clavata*	Mediterranean - non CS
Fish_teleost	*Lophius budegassa*	CS - Western Waters
	Lophius piscatorius	CS - Western Waters
	Merlangius merlangus euxinus	Black Sea
Marine_mammals	*Physeter macrocephalus*	Mediterranean - non CS
	Tursiops truncata	CS - Mediterranean
Physical_habitats	Megafauna of submarine canyons	Mediterranean - non CS
	Seafloor	CS - North Sea, CS - Western Waters, Mediterranean - non CS
Plankton	Algae	Mediterranean - non CS

Ecosystem component	Taxon	Region
	Protozoa	Mediterranean - non CS
Plants	Macrophyta	Mediterranean - non CS
Reptiles	*Caretta caretta*	CS - Mediterranean, Mediterranean - non CS

Besides input of litter, several Task 4.5 papers also studied the impacts from catch and bycatch on benthos and fish, and from physical disturbance of the seafloor on benthos and physical habitats (Fig. 4.26).

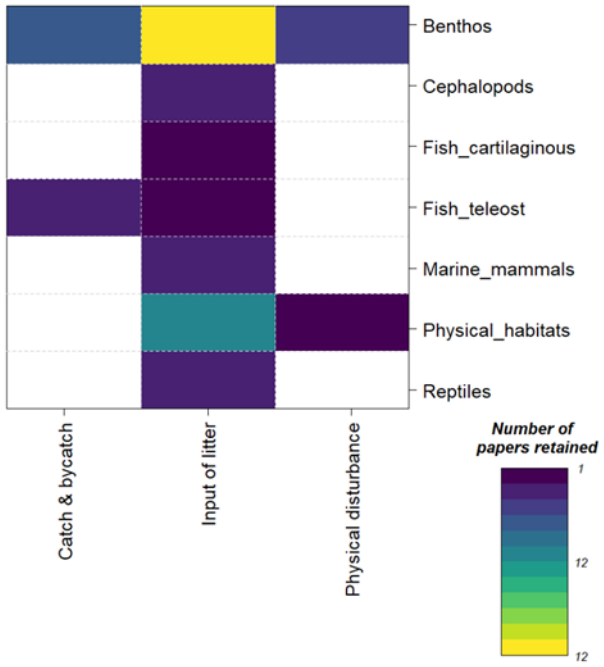


Fig. 4.26 Number of times Task 4.5 papers studied the impact of a pressure type (horizontal axis) on an ecosystem component (vertical axis). Papers may have reported on multiple pressure types.

Fishing-related impacts from litter were mostly quantified by measuring changes to abundance, biomass, or density of ecosystem components (Fig. 4.27). Papers studying 'other' as a response variables investigated entanglement, attachment, ingestion or damage/scars.

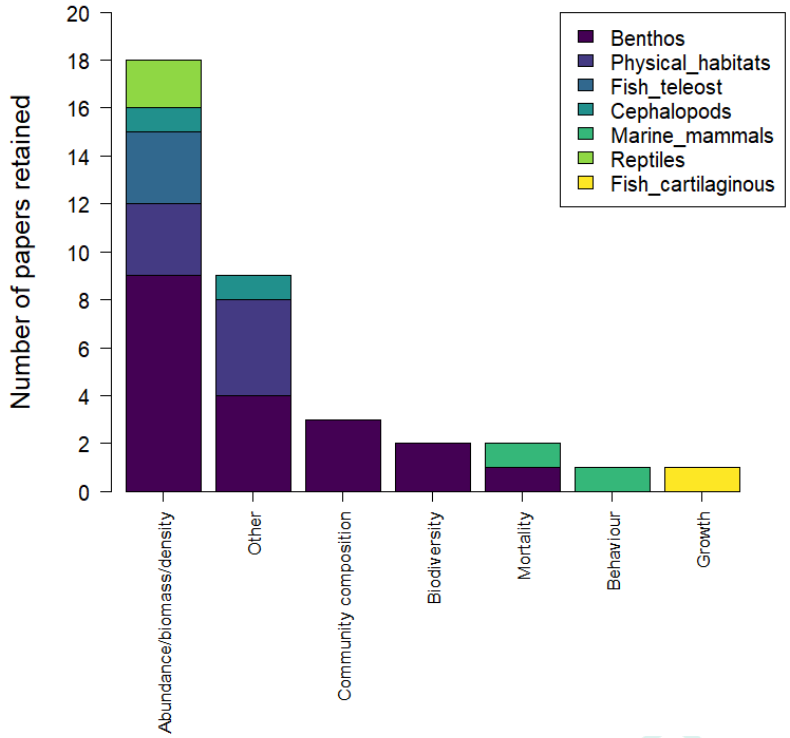


Fig. 4.27 Number of times Task 4.5 papers reported response variables by ecosystem component. Papers may have reported on multiple response variables.

Other fishing impact studies

In total, 100 papers could not be classified under any of the WP4 tasks, yet still investigated ecological impacts of fishing. From here on these papers are referred to "other fishing impact papers" and further analysed below.

Teleost fish and benthos were the most studied ecosystem components in other fishing impact papers, followed by cephalopods, cartilaginous fish and seabirds (Fig. 4.28). Impacts were published predominantly for the Mediterranean Sea, followed by the North Sea, Western waters and the Baltic Sea (Fig. 4.28).

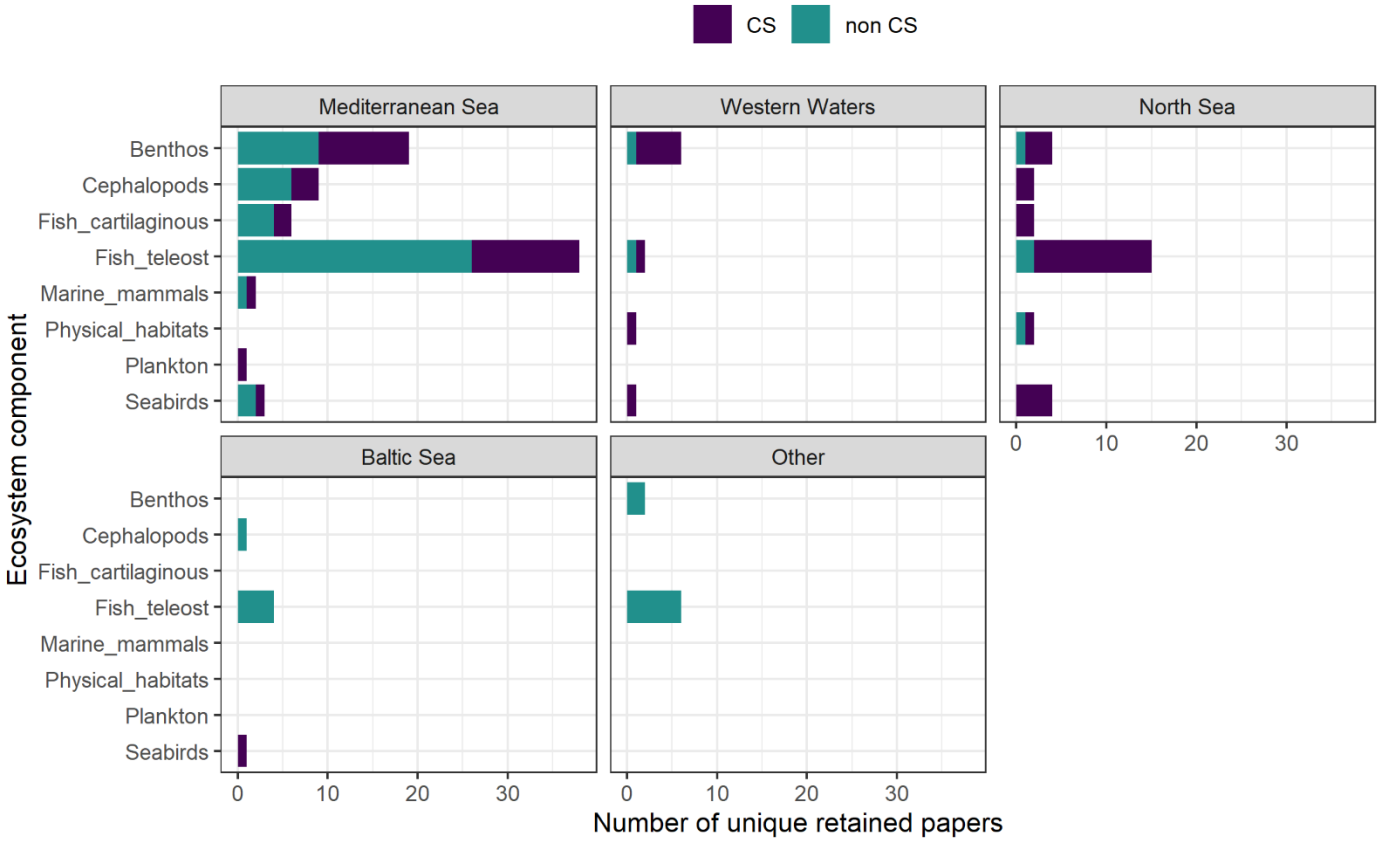


Fig. 4.28 Number of papers by ecosystem component, region and case study for other fishing impacts studies. All regions outside the case study areas were grouped as 'Other'. Papers may have reported on multiple ecosystem components. Colours indicate inside case study (CS) or outside case study (non CS) boundaries.

Catch, bycatch and discarding of target/non-target fish and benthic species were the key pressures and ecosystem components of major concern in these studies (Fig. 4.29). Catch of cephalopods and discarding of seabirds was also of interest. A few papers studied impacts of physical disturbance on several ecosystem components, the effect noise on seabird and the impact of electromagnetism on teleost fish (Fig. 4.29).

By far the most studied response variable in the other fishing impact papers was the abundance, biomass or density of ecosystem components (Fig. 4.30). Mortality/survival was of most interest for teleost fish. Behavioural responses to fishing operations were also studied for marine mammals and seabirds.

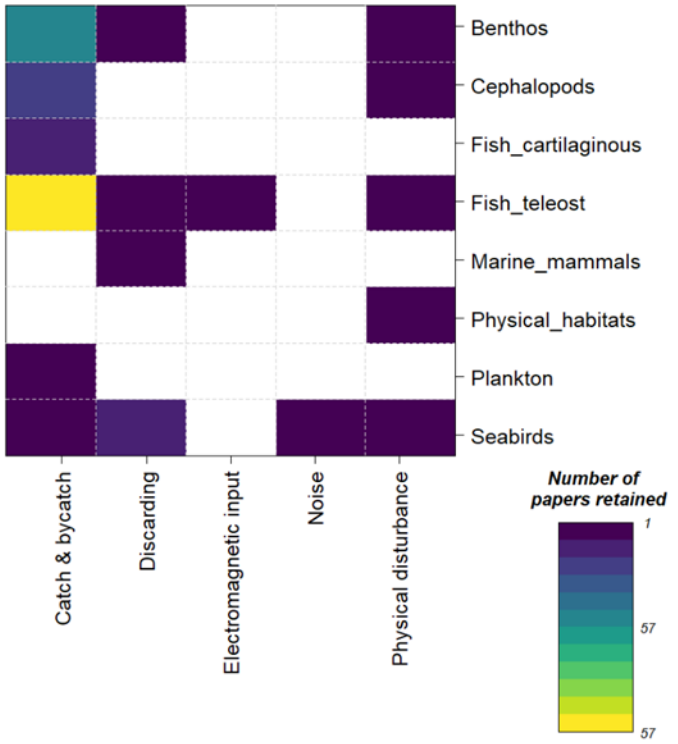


Fig. 4.29 Number of times other fishing impact papers studied the impact of a pressure type (horizontal axis) on an ecosystem component (vertical axis). Papers may have reported on multiple pressure types.

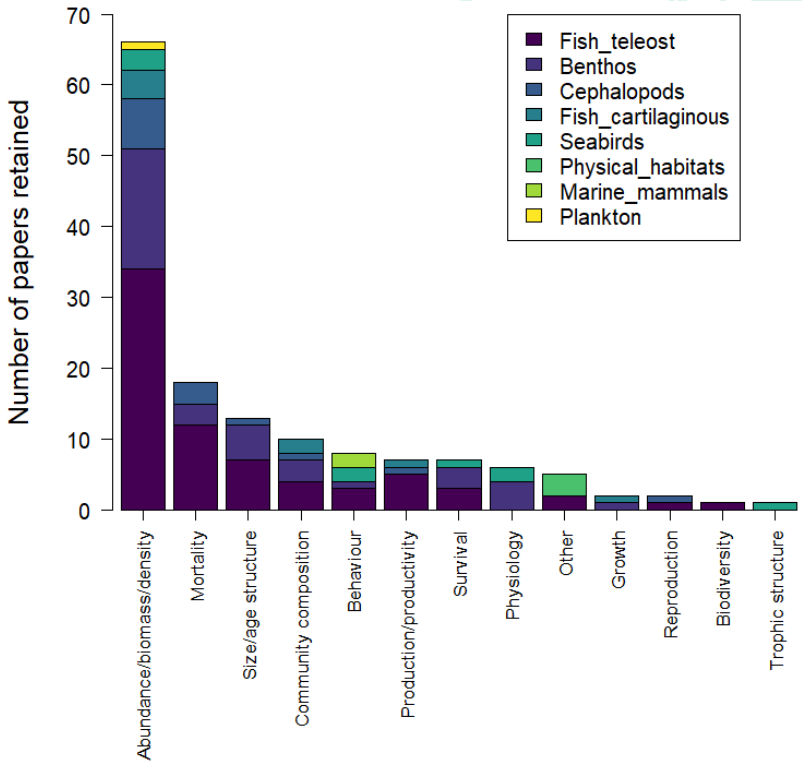


Fig. 4.30 Number of times other fishing impact papers reported response variables by ecosystem component. Papers may have reported on multiple response variables.

5. Comparison of knowledge identified by stakeholders and systematic review

The most frequently reported items across regions were species interactions, PET/sensitive species, marine mammals, seabirds, bycatch, benthic habitats, turtles, litter, invasive species and environment. In the systematic review, there was by far most information on teleost fishes and benthos. Marine mammals, seabirds and reptiles were all covered in at least 25 papers each, indicating that there is a considerable body of knowledge even though not all areas may have information for all species. Assuming PET/sensitive species refer to a combined group consisting mostly of marine mammals and cartilaginous fishes, this means that among the key topics, litter is the least frequently reported on in the literature, especially outside the Mediterranean, where scientific papers are scarce. As a consequence, areas outside the Mediterranean may lack information for further analysis unless a dedicated effort is made in SEAwise to remedy this. Additionally, the Baltic had few papers on food webs, physical habitats and benthic habitats.

The differences in topics identified in the stakeholder scoping did not reflect the differences in the amount of papers available. For example, seabirds were mentioned in the top three in both Western waters and the North Sea and marine mammals in the Mediterranean and North Sea, but were rare in papers. Litter was frequently identified as being of interest in the North Sea were papers on the effects of litter were rare in this area.

6. References

Garcia, S.M.; Zerbi, A.; Aliaume, C.; Do Chi, T.; Lasserre, G. 2003. The ecosystem approach to fisheries. Issues, terminology, principles, institutional foundations, implementation and outlook. FAO Fisheries Technical Paper. No. 443. Rome, FAO. 71 p.

7. Document Information

EU Project	No 862428	Acronym	SEAwise
Full Title	Shaping ecosystem based fisheries management		
Project website	https://www.seawiseproject.org/		

Deliverable	N°	D4.1	Title	Report on the key species and habitats impacted by fishing
Work Package	N°	4	Title	Ecological effects of fisheries
Work Package Leader	Dave Reid			
Work Participants	Gerjan Piet, Esther Beukhof, Sebastian Uhlmann, Elliot John Brown, Amaia Astarloa, Gert Van Hoey, Chris Lynam, Maria Teresa Spedicato, Karin van der Reijden, Grete Dinesen, Ole Ritzau Eigaard, Raphael Girardin, Ghassen Halouani Oihane Cabezas Basurko, Miren Altuna, Dorleta Garcia, Giovanni Romagnoni, Pierluigi Carbonara, Chris Smith, Nadia Papadopoulou, Konstantinos Tsagarakis Eugenia Lefkaditou, Katerina Anastasopoulou, Archontia Chatzispyrou, Alexander Kempf, Matthias Bernreuther, Felien Festjens, Stephie Seghers, Joanna Bluemel, Robert Thorpe, Isla MacMillan, Mikaëla Potier, Logan Binch, Jan Jaap Poos, Jochen Depestele, Søren Eliasen, Marloes Kraan, Marc Taylor, Celia Vassilopoulou, Nis Sand Jacobsen			

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Issue Date	Revision N°	Author	Change

[1]Dissemination level (DELETE ACCORDINGLY): **PU:** Public, **CO:** Confidential, only for members of the consortium (including the Commission Services), set out in Model Grant Agreement, **CL:** Classified, information as referred to in Commission Decision 2001/844/EC

[2] Nature of deliverable (DELETE ACCORDINGLY): **R:** Report, **DEM:** Demonstration, pilot, prototype, plan design, **DEC:** Website, patent filing, market studies, press & media, videos, **Other:** Software, technical diagram, etc., **Ethics:** Ethics deliverable

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27.04.2022	0.3	Esther Beukhof	Addressing review comments/edits
11.05.2022	1.0	Anna Rindorf	Added results from BSAC scoping
05.10.2022	2.0	Anna Rindorf	Added doi and suggested citation