

EXTRACT OF THE FINAL REPORT OF THE PROJECT DISCATCH

General description of the project components

Conservation standards for sustainable exploitation, within an ecosystem approach to fisheries management, increasingly urge the elimination of the wasteful practice of biomass discarding at sea. Understanding the reasons for discarding and identification of solutions to tackle the bycatches of unwanted species and specimens is essential if discards are to be eliminated without affecting the minimum requirements of conservation standards. To strengthen the scientific basis for the ecosystem approach to fisheries management the EU requires knowledge on the impact of fishing on the structure, functioning and services of the ecosystem as well as on the socio-economic aspect of innovations in fisheries technology and management. The current project will provide this basis. The success of this multi-disciplinary project, however, will critically depend on a clear a priori understanding of how these different topics are inter-linked and fit into the overall framework of the project.

The aim of DISCATCH will be to support the identification of viable solutions to address factors determining the catches of unwanted species and specimens in trawl fisheries with a view to reducing unwanted catches and eliminating discards. The main objectives of DISCATCH are:

- to provide an overall assessment of the fishing fleet discarding behaviour and to identify the main reasons for discarding in Mediterranean continental shelf demersal and small pelagic trawl fisheries.
- to identify measures, including technical ones related to fishing gear characteristics, to mitigate or eliminate bycatches of unwanted species and measures to eliminate discarding based on existing or new measures.

DISCATCH will cover seven non-adjacent Mediterranean sub-regions, as identified by the FAO Statistical Divisions, within the Western, Central and Eastern Mediterranean Basin, where relevant demersal and small pelagic trawl fisheries occur. For every Mediterranean sub region covered by this proposal, project will provide:

- a comprehensive review and analysis of scientific papers and technical reports covering fisheries for demersal and small pelagic fisheries in the selected area;
- a description of commercial yields, discard rates, selectivity parameters in relation to different mesh sizes/shapes and/or net structures through existing simulation models;
- a comprehensive analysis of the relevant data collected through the Commission Decision No 2010/93/EU adopting a multiannual Community programme for the collection, management and use of data in the fisheries sector. Where applicable, data shortcomings will be described in detail, and if needed, scientific surveys on board of commercial vessels to address such shortcomings will be performed;
- statistically significant sea trials, both for demersal and small pelagic trawls, supplemented by predictive simulation models to test the use of different mesh sizes, shapes and net structure.

To ensure that DISCATCH will provide a long term basis for partnership, all simulation models will be duly documented and will include clear visual outputs.

Executive summary

Review and analysis of scientific papers and technical reports on discards quantities, composition, practices and mitigation tools in the Mediterranean

Information concerning trawl fisheries discards in the Mediterranean Sea from scientific papers and grey literature, including technical reports has been collected. The review aimed to present an overview of the evolution of research projects on discards in the Mediterranean and to summarize available information in relation to discard ratios at the fishery and the species level, as well as on sizes of discards. Moreover, we identified reasons and factors for discarding and characterised mitigation tools and management measures for the avoidance of unwanted catches.

- the first projects started in the mid '90s involving partners from several EU countries. This increased standardization of methodologies. An important step was the integration of onboard sampling in the EU Data Collection Regulation. However, further standardization should take place, especially on raising methodologies;
- discards ratios in the EU Mediterranean bottom trawl fisheries are usually in the range 26-50% but there are cases with much lower (<20%) or higher (90%) ratios;
- discards ratios can highly fluctuate seasonally and/or annually as well as between fisheries and areas at local or basin scale;
- they also differ according to target species/group and gear used;
- discarded fractions of the so-called target species (e.g., hake, red mullets, red shrimps, rose shrimp, Norway lobster) are usually very low or even negligible (usually between zero and 10%) and comprise damaged or undersized specimens;
- nevertheless, most studies report relatively low proportion of key commercial (i.e. target) species in the catch. Thus commercial by-catch has usually higher discards ratios than the most valuable species; as an example, discarding for bogue and horse mackerels usually exceed 70% and 40% respectively;
- species-specific discards ratios also exhibit large scale geographical variations;
- despite the commercialization of several non-target species, a large number of species that are always totally discarded are included in the catch;
- discards L50s, the length at which 50% of the individuals are discarded, are small in the Mediterranean as they are based on massive catches of juveniles of certain species that can be sustained throughout the years; however there are important market demands for small individuals as well, often resulting in retaining individuals even smaller than the Minimum Landing Size;
- factors which may function as drivers for discarding were classified into four main categories, following previous suggestions in the literature: (i) natural and structural conditions, (ii) community, (iii) state (and regulations) and (iv) market, which they name "the institutional basis of discarding";
- these factors often act in synergistic effect which may not be straightforward to disentangle, especially in multi-species fisheries like most of those exerted in the Mediterranean;
- natural conditions (e.g., depth, productivity, substrate type), affect species composition, abundance and size structure of the catch, which in turn influence fishers' behaviour;
- fishing strategies and legal constrains substantially affect composition and quantities of discards;
- still, discarding in the Mediterranean is mainly regulated by market demands;
- geographical differences, apart from the effect of natural conditions, seem to be related to socio-cultural characteristics such as community welfare, nutritional habits and familiarization with some species, which affect market demands;
- mitigation tools mainly comprise selectivity improvement and spatio-temporal closures;

- several gear modifications (mesh size and shape, sorting grids, codend circumference) have been tested leading in an increase in mesh size during the last years, while trials are still ongoing since it is a dynamic field;
- spatio-temporal closures mainly aim the avoidance of charismatic species and/or undersized fish and invertebrates and can provide effective solutions;
- among the remaining mitigation tools the MLS mainly aims to discourage fishing juvenile fish, however it is possible that discards quantities increase in some cases due to discarding of unavoidable undersized catch;
- however, a whole set of tools, mainly awareness campaigns and economic incentives for more selective fishing (e.g., selective licensing, eco-labelling) are totally absent or have had very limited application in the Mediterranean Sea.

Data Collection Framework analysis

The main subject was represented by the particularities of inherent Mediterranean onboard sampling data, the exploration of data collection framework sampling strategies, precision and accuracy and different methodological approaches related to the analysis of discard data. Indeed, the use of modelling approaches to analyse the discard process might help to disentangle the effects of different drivers, allowing insights into the potential effectiveness of technological and area/time management measures for reducing fishery discards.

The purposes were:

- 1) to explore the possibilities of the use of a common format for Atlantic and Mediterranean EU seas, such as Fishframe format. Moreover, a review of Mediterranean fishery monitoring programmes under DCR and DCF EU regulations, allowed an exploration of their bias, weakness and gaps.
- 2) The use of Generalised Additive Models (GAMs) allowed to explore the main drivers of discard process through exploratory variables linked to spatial (for example linked to the position of nursery areas), temporal, technical (for example influenced by the selectivity process) and economic (for example linked to the economic values of the catches).

Using Hierarchical Bayesian models describe discarding behaviours and factors influencing discard rates on their spatio-temporal pattern. This study was focused in modelling total discards and discard ratio, in order to characterize the factors that influence discards. Although the Mediterranean fishery research group in the Regional Coordination Meeting for Data Collection Framework (*Report of the 10th Regional Coordination Meeting for the Mediterranean and Black Sea 2013, point 4.1: Regional database: update/actual status since 2012, and Annex III*) as a responsible working group implementing the EU Commission questions and reweaving the data collection framework (DCR/DCF) and development in the different countries at generic terms, was expressed their intention to maintain a separated database at different aggregation levels and with different accessibility from countries to EU level, it could be interesting to create a working group to bring postures closer in order to establish common and comparable data framework to catch and discard data over different aggregation figures for the Atlantic and Mediterranean countries.

Quality data, spatial and temporal coverage, sampling intensity, and fishery data availability analysis indicates a common basic information from on-board sampling programmes for the Mediterranean countries. Notwithstanding it will be improved throughout establishing different basic step by step procedures to gathering data. Based on models information it will be improved discards rates estimation and spatial and temporal discards estimation by species distributions particularities for the trawl Mediterranean fishery. On the basis of analysis carried out, a more in deep exploration of the selectivity parameters of the fishing gears, of the consequences of different mesh sizes on the amount of discard and on the population at sea would be needed.

Predicting commercial yields, discards rates and selectivity by towed gears from fishing gear characteristics

The most advanced simulations models in FISHSELECT (Herrmann et al., 2009), which can simulate the basic size selective properties for nettings with arbitrary mesh shape and size for different fish species, have been used. For trawls these methods are developed so as to provide reliable predictions (Herrmann, 2005; O'Neill and Herrmann, 2007). The specific objectives are: i) to predict the expected size selectivity of a range of species for many different codend constructions (e.g. mesh sizes, mesh type, twine thickness); ii) to validate the model results using selectivity data from

both the pelagic and demersal fisheries. We analysed currently legislated codends and different designs not tested at sea. We estimated the selectivity propriety for three different mesh geometries: diamond-, square- and hexagonal-mesh. A total of 11 species were investigated: 2 pelagic (anchovy and sardine), 5 demersal fish species (hake, Mediterranean horse mackerel, European horse mackerel, red mullet, striped red mullet and 4 crustaceans species (giant red shrimp, red shrimp, deep-water rose shrimp, Nephrops). Simulation results allowed us also to conclude that in most Mediterranean bottom trawls, opening angle of diamond mesh codends usually spans from 25° to 60°, with majority being between 30° and 40°. Finally, the basic selective propriety of each mesh, were collected in a design guide, which are plots showing simulated L50 as isocurves for a range of mesh size versus mesh openings for each mesh type. The design guide can be used to identify the conditions required to obtain a specific and constant selection during a fishing process and therefore they are critical for management purposes, because they allow setting the desired selection parameter ranges based on the two key technical parameters.

Quantifying, modelling catch and discard composition in trawl net fisheries

BEMTOOL simulation approach

BEMTOOL simulation approach has been used in the DISCATCH project with the aim to forecast the effect of different mesh sizes/shapes scenario on spawning stock biomass of target species, commercial yields and discards rates, as well as to assess the different performances of selected technical measures on population, production and economic indicators. Three case studies have been implemented: on the demersal fishery of GSA 18 (south Adriatic), in GSA22 (Aegean Sea) and on GSA16 (Strait of Sicily). As reported in the EU-LANDMED project (2015), the results of the selectivity study confirmed the lack of size selectivity for the mid-water trawling and purse seiners; for these two gears the increases in selectivity is very difficult to achieve. The use of large meshes in the codend has been tested in the Chioggia harbor with results not satisfactory. In fact, if large meshes are used in the codend of pelagic trawl, there could be the possibility that the anchovies entering the codend can be gilled or enmeshed. For this reason, simulations have been carried out only for demersal fisheries case studies of Table 1 in WP 3, as for demersal species gear selectivity can be considered a technical measure able to contribute at improving the exploitation pattern of the affected stocks.

In GSA 18 (target species European hake, deep water pink shrimp, Norway lobster, red mullet) and GSA16 (target species European hake, deep water pink shrimp, and giant red shrimp), for status quo scenario a diamond mesh of size 50 mm have been assumed and then compared to:

- a square mesh of size 50 mm;
- hexagonal mesh of size 50 mm.

The selectivity of the other gears remained unchanged in the projections. In GSA 22, for status quo scenario a diamond mesh of size 40 mm has been assumed and then compared to:

- a diamond mesh of size 50 mm;
- a square mesh of size 50 mm;
- hexagonal mesh of size 50 mm.

The selectivity of the other gears remained unchanged in the projections. The scenarios of improved selectivity were designed for four species (Hake, Deep-water pink shrimp, Red mullet and Horse mackerels). The BEMTOOL simulations allowed exploring the effects of different selectivity scenarios on the relevant indicators. In particular, the focus was on SSB, overall catch, landing, discard, discard ratio, mean length in catches, revenues and average wage indicators. The main findings of BEMTOOL can be summarized as follows.

- The 40D mesh represents the configuration producing the smaller level in SSB respect to the other configurations, while the 50S mesh size corresponds to the highest improvement in SSB;
- In the medium term the 50S mesh allows to obtain the highest catches, while the 40D the lowest;
- In the short and medium term the 50S mesh allows to obtain the lowest discard amount and discard ratio, while the 40D mesh the highest;

- The increase in mesh size of trawlers determines an improvement of the catches also of the other gears, because the smaller individuals left by the trawlers are left to growth and are then available to them, thus can be caught at higher sizes by all the gears (trawlers and not);
- The 40D mesh represents the configuration producing the smaller mean length in catches respect to the other configurations, while the 50S mesh size corresponds to the highest mean length, that in turns could implies more valuable products ;
- The 40D mesh represents the scenario producing the lowest revenues and average wage, while the square scenario corresponds to the highest ones;
- For all the points the hexagonal mesh gives intermediate results.

For the case study in GSA 22 the two approaches BEMTOOL and EwE have been applied in a complementary way, i.e. the outputs of the bioeconomic population model in terms of fishing mortality by fleet and species for the different harvesting scenarios are used in the ecosystem model to design the scenarios in respect to the reference scenario (gear mesh size 40D). The specific objective of Task 4.2 of DISCATCH was to investigate ecosystem effects of improved trawl selectivity in the NAS.

Ecosystem modelling integrates available information to study direct and indirect trophic interactions among ecosystem compartments, including fishing activities and the environment. We used as basis a previously developed Ecopath model representing the North Aegean Sea ecosystem in the mid-2000s in order to construct a model for the early 1990s and to further develop its time dynamic module (Ecosim) calibrated with time series. This calibrated model aims to constitute a tool to investigate policy options towards an ecosystem-based management of fisheries in the North Aegean Sea.

- The 1990s model has 40 Functional Groups (FGs) (38 living FGs, and two detritus FGs) and considers five fishing fleets: (1) bottom trawls, (2) purse seines, (3) static nets, (4) longlines and troll baits and (5) pots.
- Input data included bottom trawl and other surveys, landings and discards information, as well as information on biological parameters and feeding habits from the literature.
- Time series of biomasses for the period 1993-2008 were used to calibrate the model in the sense of optimization of the trophic interactions among the FGs. Fishing effort data (1993-2010) and an environmental anomaly variable were used to drive the model.
- Increasing trends under the improved selectivity scenarios were observed for Total Catch, Catch/Biomass and Fisheries in Balance index, while the mean Trophic Level of the Catch was almost constant. According to these, the ecosystem wide exploitation status showed improvement under increased selectivity.
- The biomass of shrimps decreased in the short term but increased in the long term, red mullets were relatively constant while small and large improvements were simulated for hake and horse mackerels respectively. These responses were the result not only of modified F but also of changes in predation, prey availability and competition.
- Yield decreased for these four species except horse mackerel whose population increase was large enough to overcome the decrease in F.
- Spill-over effects concerning biomass and yield were observed for several FGs. Total biomass increased - depending on the scenario- by 0.5-2% and by 0.9-3.9% after five and ten years of simulations respectively. The increase in total yield was higher and reached 2-7.8% in the long term.
- Improved selectivity seemed to affect the whole spectrum of the food web, including mid and high trophic level functional groups (FGs) but also pelagic and demersal/benthic ones. This is because of the complexity of the food web and the benthic-pelagic coupling. The FGs that seemed to benefit more were top predators while the biomass of prey FGs decreased in most cases.
- Among the scenarios the 50S had the best response on the food web and the ecosystem components, while 50S and 50H showed similar results, slightly improved compared to the reference one (40D). These improvements were more obvious in the long term (decade). It seems that the ecosystem as a whole and its components could benefit from improvements in selectivity but benefits may not be evidenced immediately.

Ecopath with Ecosim approach

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- The scenarios of improved selectivity for four species (Hake, Deep-water pink shrimp, Red mullet and Horse mackerels) were set based on the BEMTOOL outcomes from DISCATCH Task 4.1. These included (i) a reference scenario with 40mm Diamond (40D) mesh which was applied in the area at least until 2010, (ii) a 50mm Diamond mesh (50D) which is stated in the the EC Reg. 1967/2006 and two more selective mesh configurations (iii) 50mm Square (50S) and (iv) 50mm Hexagonal (50H). Relative (compared to the reference scenario) fishing mortalities from BEMTOOL outputs were used as inputs for the EwE scenarios.
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Framework and synthesis

An evaluation of national discards programs has been done by identifying all potential loopholes in methodology. Different technical and environmental factors that influence discard rates have been identified and summarized. Furthermore, selective properties of demersal and pelagic trawls have been summarized in relation with the MLS and landing obligation Regulation, in order to assess the efficacy of these technical measures. Finally, the stakeholder's perceptions on the discard issue and their opinions and options have been integrated. The main results achieved have been:

- Discard amount fluctuates among fisheries and areas, usually from < 20 % to 70 %, due to a biological, technical, environmental, legal and socio-economic factors.
- The complexity of the fishing activity in the Mediterranean basin is influenced by many factors: multi-target species, the geographical peculiarities, the multi-gear use, the seasonality etc.
- The Mediterranean onboard national discard programmes seem to have low levels of bias in the sampling protocols, with the higher level of risk of bias linked to low sampling coverage and landings and effort statistics.
- Discarding in the Mediterranean is affected by numerous reasons and several factors which is difficult to disentangle (commercially unimportant invertebrate and fish species, commercially important but undersized species (under MLS), commercially important species which fishermen could not sell on the market or have very low market price).
- High regional, seasonal and interannual fluctuations are observed even within the same fishing gear.
- Increased discarding of some species has been reported during the recruitment period when they migrate from shallow waters to off-shore areas accessible to bottom trawling.
- Fishing depth has been greatly related to patterns in discarding, obviously due to varying catch composition and the relative biomass of target species in the different depth strata even if there doesn't seem to be a constant pattern related to the depth stratum for the whole basin.
- The availability of resources, sometimes affected by the status of the stocks, has been shown to affect fluctuations of market demands and associate discarding practices.
- Fishers' attitude, approaches practiced and experience, both the captain's and the crews have been also shown to affect discards.
- Nutritional habits of the community affect fishing and discarding practices. At small scale, some species may be marketable only in some areas.
- At larger scale, discards ratios for trawls are generally lower in the easternmost and southern basin.
- The low level of discarding of MLS-regulated species in certain Mediterranean trawl fisheries may be a consequence of a quota-independent management system of demersal trawl fisheries and, even more importantly, a consequence of low compliance by fishermen and weak control and enforcement in certain areas.
- Market demands rather than fish size (legal reason) determines what is discarded in Mediterranean fisheries.
- The existing MLSs are ecologically inefficient for sustainable management and MCRS should be redefined for several species.
- Mediterranean trawling produces the bulk of discards and this is the reason why most studies focus on trawling activities. In general, fisheries targeting fish or mixed categories presented higher discard ratios compared to the ones targeting shrimps. Several shrimp fisheries operate throughout the Mediterranean with varying generation of discards according to the species targeted and the depth stratum that they operate
- The majority of selectivity studies were focused on the species that have highest commercial values; some studies show that a simple change from a 40 mm diamond to a 40 mm square mesh improves the selectivity for some target species, it also results in economic losses due to escapement of some accompanying species;
- The MLS of species commonly caught in Mediterranean trawl fisheries are not harmonised with the species length at first maturity, indicating that most of the species that are caught are not allowed to spawn at least once in their life time.
- All these suggest that current codends used in Mediterranean trawl fisheries are not adequate and that some additional improvements in selectivity are needed.

The deliverable ***Errore. L'origine riferimento non è stata trovata.*** offered the opportunity to contribute further to our understanding of factors that drives fishers' behaviours to a higher or lower discard level and also towards exploring effective discard mitigation measures. The main results achieved have been:

- At the level of the fisher, the act of discarding involves a short term economic decision

- Economic, regulatory and environmental/natural factors, as well as individual characteristics related to the fisher, fishing operations and vessel seem to have a synergistic effect in the decision-making process of discarding, which is sometimes difficult to disentangle.
- The efficacy of technical measures (eg. Minimum Mesh Sizes (MMSs), Minimum Conservation reference Sizes (MCRSs), closed areas and seasons) mainly depend on the level of rule compliance and enforcement effort, on the collaboration between fishermen and the willingness of fleets to share information.
- Stakeholder engagement showed that cost compensation, commercialising species caught in a sustainable manner and overall economic incentives have been seen positively as potential interventions.
- Concerns have been expressed about providing discards to the fishmeal industry and aquaculture, needed facilities and infrastructure and control/fines, which are already strict. The main concern was that if the landed discards can be re-used for other purposes, (fishmeal for instance), fishermen will be stimulated to catch more fish.
- Reducing discarding is a complex issue which involves combinations of management measures (e.g., use of avoidance and gear selective strategies along with campaigns to increase awareness) or a single method/tool.
- Reducing discards should be designed for specific fisheries and fleet characteristics and may differ between regions.
- Reducing discards should incorporate stakeholders' knowledge and in particular fishers since they have unique knowledge concerning local features, needs and better understanding of impacts of measures.
- Reducing discards should take human behaviour into account as an important source of variability.

In the deliverable ***Errore. L'origine riferimento non è stata trovata.*** different combinations of scenarios developed in each study area/fleet that will advise on the effects of selectivity-related management measures have been reviewed together with the results obtained from the two stakeholders meetings.

- Approaches contributing to discards mitigation in the Mediterranean mainly comprise technical measures, which are related to improvement of selectivity and/or avoidance of potential hot spots of discards.
- Technical measures may be gear- and fishery-specific and their application should be tested in different areas
- Trawl selectivity indicator graphs provide a good opportunity to compare MLS and lengths at first maturity. The results show that the Lengths at first maturity for the investigated DISCATCH species for the majority of species show that MLSs are well below the size at first maturity.
- This goal can be achieved by promoting bottom trawl replacement with more selective fishing gears or promoting changes to the selective performance of bottom trawling through technical changes (square mesh codend, sorting grids etc.).
- Many studies highlight the advantages of the use of a square mesh instead of a diamond shaped due to the fact that square mesh tends to keep shape and stay open, better than diamond mesh.
- The existing MLSs are ecologically inefficient for sustainable management; thus, the selective performance of bottom trawls in the Mediterranean Sea should be improved in order to fulfil ecological and biological targets.
- Spatio-temporal closures for specific fishing gears exist and they usually aim to protect juvenile fish
- The designation of spatio-temporal closures in the GFCM area is not always based on scientific criteria and they often try to satisfy social demands. A more targeted designation, based on scientific results may prove more effective in by-catch reduction and fisheries management in general
- The results of stakeholders meeting show that there is not a clear trend of the topics that stakeholders consider as having a paramount importance.
- The costs to shift from the traditional to more selective gears is the most important topic for stakeholders, who consider any modification of the gear needed to reduce discarding should be funded by the national authorities or by the EU.
- Stakeholders seem to be not available to pay for more selective gears; on the other hand they also consider that retaining and selling undersize fish shall not increase their income, mainly because the undersized fish products are not effectively utilized.

- Stakeholders consider the current design of bottom trawl gears as highly unselective and they seem to be well aware of the potential positive effects of improving selective form an ecological (discards reduction, positive effects on the biodiversity) as well as technological (better catch quality and marketing opportunities, reduction of time devoted to sorting the catch ecc.) point of view.
- The stakeholders consider the maintaining of a safe level of reproductive potential as one of the main management objectives while the discards reduction is perceived as a minor issue.
- As regards the ecological indicators the most important issue seems to be the “mean size of the spawners”.
- Considering the economic indicators, the stakeholders gave their preference to “revenue” in comparison to “production” and to “fuel costs” in comparison to “crew costs”.
- Stakeholders consider the “fleet withdrawal” (scraping) as the worst option for the management strategies to achieve a sustainable fishery management in the long term
- The combination of three measures is considered as the best option: Spatial fishing ban (Protection of nursery and spawning areas), seasonal fishing ban, improved gear selectivity.
- Overall, the stakeholders do not consider the discards ban implemented in the framework of EU Reg. No 1380/2013 as a proper management measure to improve the status of the commercial stocks since: 1) there is uncertainty on the long term gains; 2) the retaining and selling of undersized fish will not increase their income; 3) the compliance with the EU provision will not easily be achieved.

Establishment of stakeholders' platform and project information management

The consortium partners, who represent considerable expertise in the fishery science and a range of key stakeholders, organized in a multi-stakeholder platform (MEDAC, Mediterranean Advisory Council) have interacted in this project to make sure scientific findings were grounded with real and up-to-date knowledge of what happens at sea, such as the one fishermen have. The multi-stakeholder platform to ensure interaction with all relevant stakeholders in the fishery sector has been established through the organization of a more interactive website used to inform and get feedback from stakeholders. In addition, the organization of two large multi-stakeholder events ensured the interaction between stakeholders and scientists at the beginning using a survey with a questionnaire and at the end of the project using Multi-Criteria Decision Analysis (MCDA) techniques to address and finally consent on complex issues among many participants, with different background, knowledge and, sometimes, conflicting objectives or preferences. Bottlenecks, challenges, and solutions or mitigation strategies were presented at the stakeholder events based upon state-of-the-art of knowledge for the sector.