BADMINTON (Bycatch And Discards: Management Indicators, Trends and locatiON)

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Skýrsluágrip Matís ohf
Icelandic Food and Biotech R&D

Report summary

Titill / Title	**BADMINTON** (Bycatch And Discards: Management Indicators, Trends and locatiON)
Höfundar / Authors	Sveinn Margeirsson, Sigríður Sigurðardóttir, Elísabet Kemp Stefánsdóttir, Jónas R. Viðarsson.
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Ágrip á íslensku:

Meginmarkmið verkefnisins var að afla þekkingar um brottkast mynstur í Evrópu og meta skilvirkni aðgerða gegn brottkasti, þar með talið skilvirkni veiðarfæra. Annað markmið var að bæta aðferðir til að meta og stjórna meðafla og brottkasti.

Tvær meginaðferðir voru notaðar í verkefninu. Í fyrsta lagi var notast við gögn sem var safnað undir *the European Union Data Collection Regulation* (2002) síðar *the Data Collection Framework* (2008). Þar er um að ræða gögn safnað á landsvísu þar sem eftirlitsmenn fylgjast með veiðarferð og skrá afla og brottkast. Gögn af þessu tagi hafa nokkra vel þekkta galla, það er dýrt að safna þeim og þau hafa óhjákvæmilega bjaga, en eru engu að síður mikilvæg upplýsingaveita. Í þessu verkefni voru þessi gögn sameinuð fyrir nokkur lönd innan Evrópusambandsins. Það var flókið ferli þar sem aðferðir við söfnun gagnanna var mismunandi milli landa. Sú undirbúningsvinna mun koma sér vel fyrir framtíðarverkefni, þar sem ætlunin er að nýta gögn fyrir fleiri en eitt land.

Ekki er hægt að skilja hegðun manna til fullnustu með athugunum á tölulegum gögnum. Að skilja brottkast er engin undantekning þar á. Því voru einnig tekin viðtöl við hagsmunaaðila og sérfræðinga um sjónarmið þeirra á brottkast vandanum. Vonast var til að viðtölin myndu bæta við þá þekkingu sem fékkst með greiningu fyrirgreindra gagna.

Þessar tvær leiðir sem verkefnið notaðist við leiddi til sömu tveggja meginniðurstaðna. Í fyrsta lagi að mikill munur er á brottkastmynstrum eftir veiðisvæðum, löndum, veiðarfærum, stærð skipa og tegundum. Það virðist sem munurinn sé mestur milli veiðisvæða og þar með að best sé að reglugerðir um brottkast séu aðlagaðar hverju svæði fyrir sig. Í öðru lagi virðist brottkast, magn, mynstur og samsetning þess, ráðast af mörgum þáttum. Sérstaklega virðast núgildandi reglugerðir (*EU Common Fisheries Policy*) og samspil mismunandi þátta hennar hafa mikil áhrif. Þar af leiðandi verður gagnsemi mismunandi aðferða til að minnka brottkast erfitt að meta. Miklu skiptir hvaða aðferðir eru notaðar í sameiningu.

Lykilorð á íslensku:	*Brottkast, Nýting aukaafla, Brottkastsbann*

Skýrsluágrip Matís ohf
Icelandic Food and Biotech R&D

Report summary

Summary in English:	Discarding keeps being an important issue in world fisheries; it is a way for fishers to adjust their landings to the legal and market constraints, but is largely considered as a waste of rare natural resources and as contributing to the depletion of stocks bearing a high fishing pressure. Many jurisdictions, including the European Commission, are preparing regulations to reduce or ban discards. To design effective regulations, an understanding of the extent and processes of the issue is required.
	The MariFish BADMINTON project aimed to build up the knowledge of discarding patterns and factors in European fisheries, evaluate the efficacy of selective devices and other discard management measures that have been implemented in the past, and improve methods to analyse, monitor, and manage bycatch and discarding. Specific objectives included the provision of discard estimates for selected European fisheries, and of appropriate indicators; the determination of the most important factors affecting discard amounts and composition; and the elaboration of integrated management approaches to the discard issue.
	BADMINTON relied on two types of approaches to fulfill these aims and objectives. First was the analysis of onboard observer data, since intensive collection of catch and discard data onboard commercial vessels has been undertaken in European countries under the European Union Data Collection Regulation (2002) followed and intensified by the Data Collection Framework (2008). Thus, one significant contribution of the project was to collate onboard observer data from several European Union member states, given the many differences between national onboard observer programmes sampling schemes, protocols, details of data recorded, and data storage formats. This first step paves the way towards a future better integration of national onboard observer programmes. The second approach was to conduct stakeholder interviews and expert consultation, which was meant to complement the data analyses with fisher's perspectives on the discard issue, and to provide an integrated approach toward management.
	Both approaches lead to the following two broad conclusions:
	- Discard patterns exhibited high diversity across regions, countries, gear types, vessel sizes, and species, with variability being more pronounced among regions. Thus, discard management approaches might be devised at a regional level – consistent with the proposed regionalization of the currently discussed reform of the European Union Common Fisheries Policy. - Discards amounts, patterns, and composition, are determined by a multitude of interacting natural and human (economic and social) factors in a given place and time, and usually no simple explanations can suffice.
	The project has developed a number of tools, distinguished in three categories ie. - selectivity related tools - tools to appraise and understand the discarding issue - tools that can be used to assist in devising management strategies
	A discard management strategy should not include only a combination of discard mitigation measures; if discards are to be reduced, appropriate and consistent incentives need to be mended together.
English keywords:	*Bycatch, Discard mitigation measures, Discard ban*

Efnisyfirlit

Þáttakendur í verkefninu af hálfu Matís

Sveinn Margeirsson, PhD í iðnaðarverkfræði, verkefnisstjóri.

Sigríður Sigurðardóttir, PhD nemi í iðnaðarverkfræði, hefur séð að stærstum hluta um framkvæmd SVÓT greininga og unnið upp úr þeim grein sem er nú verið að undirbúa fyrir birtingu.

Elísabet Kemp Stefánsdóttir, MS nemi í hagfræði, hefur unnið í samstarfi við Sigríði að SVÓT greiningum og óbirtrar greinar um þær, sem og að tölfræðilegri greiningu brottkastsgagna.

Jónas R. Viðarsson, MS í umhverfisvísindum, hefur unnið að greiningu á viðhorfum sjómanna og annarra hagsmunaðila varðandi brottkast.

Verkefnið var unnið í góðu samstarfi við **HCMR, IFREMER, IMARES, Instituto Español de Oceanografía (IEO), CEFAS, Innovative Fisheries Management (IFM)** og **DTU-Aqua**.

Ágrip (markmið og niðurstöður)

Meginmarkmið verkefnisins var að afla þekkingar um brottkast mynstur í Evrópu og meta skilvirkni aðgerða gegn brottkasti, þar með talið skilvirkni veiðarfæra. Annað markmið var að bæta aðferðir til að meta og stjórna meðafla og brottkasti.

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Ítarleg umfjöllun um niðurstöður hvers vinnupakka má finna í meðfylgjandi skýrslu.

Birtar skýrslur (og skýrslur sem bíða birtingar)

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Herrmann, B., M. Sistiaga, K. N. Nielsen, and R. B. Larsen. 2012. Understanding the size selectivity of redfish (Sebastes spp.) in North Atlantic trawl codends. J. Northw. Atl. Fish. Sci., 44: 1–13. doi:10.2960/J.v44.m680

Tæknileg lokaskýrsla (á ensku)

Vísað er á meðfylgjandi lokaskýrslu (Final report) til frekari upplýsinga.

The BADMINTON [Bycatch And Discards: Management INdicators, Trends and location] project had the following aims:

- Develop the knowledge of discarding patterns and factors in European fisheries.
- Evaluate the efficacy of selective devices and other discard management measures that have been implemented in the past.
- Improve methods to analyse, monitor, and manage bycatch and discarding in European fisheries.

The project consisted of five main steps which should meet with given aims:

1. A descriptive analysis of total catch in terms of species and size composition, based on the data collected onboard EU vessels under the Data Collection Regulation. This includes a quantification of spatial and temporal distribution and abundance of discards.
2. The development of indicators of discard issues: indicators of discard state (amounts and characteristics of discards), of the pressures that determine discards (selectivity of fishing), and of the management responses to this issue.
3. An analysis of the factors that determine discard amounts, including environmental settings, year-class strength, community composition, and fishing practices. This includes an examination of the efficiency of technical regulations currently in force, and retrospective analyses of the efficiency of such measures in the past.
4. An analysis of socio-economic and institutional drivers and incentives that influence fishers' behaviour in regard to selectivity and discard.

5. Based on all previous steps, the elaboration of potential mitigation measures. Beyond technical measures, integrated approaches that will remove or at least reduce incentives to discard should be aimed at.

Matís contribution was to lead the work of the fifth step (work package 5). Deliverables specified for this work package were:

D1. A report with technical measures for discard minimization and proposed improvements.

D2. Manuscript of a peer-reviewed article on simulation results regarding optimal size and shape of mesh and technical measures.

D3. Manuscript of a peer-reviewed article on the strengths and weaknesses of different fisheries managements systems with regard to discard.

According to the project time schedule the project should be finished in September 2012. Also after work packages one to four were finished work package five should have some time to finish their work. The project was in total delayed and since many earlier work packages were supposed to contribute to work package five their delay resulted in delay off work package 5. Despite all this the project is ending only two months later than expected and hopefully all articles to be published will be submitted before the end of 2012.

An article, *How can discards in fisheries be mitigated? SWOT analysis of discard mitigation measures*, to be submitted to ICES Journal of Marine Science will fulfil both deliverables D1 and D3. Mitigation measures evaluated in the article were identified after a thorough discussion and literature review on different fisheries management systems. They are:

1. Temporary/Spatial restrictions.
2. Selective practices.
3. Improving existing and/or finding new markets.
4. Change of MLS.
5. Change of catch composition.
6. Multi-species quota.
7. Catch quota, not landing quota.
8. Discard ban.

9. Fishing effort and capacity.

10. Transferability of quota.

11. Co-management.

12. Society awareness of discard issues.

Each mitigation measure is evaluated using SWOT-analysis performed by scientists who all have expertise in fisheries science. Main results from the SWOT-analysis and results from analysis on how each mitigation measure could be complemented by other mitigation measures under analysis are discussed in the paper. Results give a thorough description on strengths and weaknesses of each mitigation measure as well as guidance for their implementation.

Three of the mitigation measures, change of catch composition, multi-species quota and society awareness of discard issues, are based on new ideas and therefor evaluation of them could not be performed. But recommendations on their implementation were included as possible.

To show an example of results drawn in the article, preliminary results for *Temporary/Spatial restrictions* are shown:

Temporary and/or spatial restrictions are widely used and have shown to be effective for many fisheries. They have shown to increase stock and have a high compliance rate. It can be used to encourage fishermen´s use of other mitigation measures, for example could restrictions involve imposing selectivity. Other mitigation measures, such as change of MLS and catch composition, can have a knock on effect on temporary and/or spatial restrictions. Downsides of this mitigation measure are the shift of fishing effort to other areas but this could be controlled to some extent with controlled fishing effort and capacity. The transferability of quotas will limit the mismatch of vessel's existing quota when displaced from an area with a closure. Lastly, temporary/spatial restrictions could be complemented with co-management as the restrictions could be more accurate if they are based on fishers' experience.

The article could act as an input for fisheries manager choosing methods to mitigate discards. Choosing between mitigation measures described can be done with more knowledge on their strengths and weaknesses and which combination of mitigation measure can be done with better knowledge of their common effect. Another benefit for fisheries managers is to use recommendation for implementing the mitigation measures.

D2 was finished with a publication in Journal of Northwest Atlantic Fisheries Science. The article, *Understanding the Size Selectivity of Redfish (Sebastes spp.) in North Atlantic Trawl Codends,* with Bent Herrmann from DTU Aqua as first author, describes a study on the size selectivity properties of diamond mesh codends on redfish. The so-called FISHSELECT methodology was further expanded and applied to available published data for redfish with new sea trial data and FISHSELECT predictions into a single comprehensive quantitative framework. FISHSELECT is a fish morphology data- and simulation based methodology that can be applied to investigate the basic size selective properties of meshes of different shape and size for individual fish species. The methodology has been successfully applied for cod (Gadus morhua) and haddock in the North Atlantic. However, cod and haddock belong to a different fish family (Gadidae) than the redfish (Sebastidae). This difference has potential implications for selectivity studies as the general body shape of the Sebastidae species in question differs substantially from that of the Gadidae species mentioned.

The method and data presented in this study could also form the base for investigating the size selection of redfish species in other fishing gear devices than diamond mesh codends. For example a design guide describing size selection of S. marinus in square mesh codends could be constructed based on the data described in this paper by using the method described in a case study for haddock in Krag et al. (2011).

The ability to reproduce the complex characteristics of the cross-section shapes of S. marinus using the mathematical description for the drop-shape family of models, which requires only two independent parameters to be estimated as function of fish length, highlights the power of this type of parametric description to model the cross-section shapes of fish. This type of mathematical description could in the future be applied to other fish species. Further, it could also be applied as a tool to categorize fish species morphologically

according to their mathematical description. The selection of different models to describe the transversal contour of S. marinus at different positions along its length also represents a new way of quantifying how its shape changes along its length.

Articles:

Sigurðardóttir, S., E. K. Stefánsdóttir, H. Condie, S. Margeirsson, T. L. Catchpolec, J. Mª Bellido, S. Eliasen, R. Goñi, N. Madsen, A. Palialexis, S. S. Uhlmann, V. Vassilopoulou and M. J. Rochet. In preparation. How can discards in fisheries be mitigated? Strengths, Weaknesses, Opportunities and Threats of potential mitigation measures.

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Fréttatilkynning

BADMINTON [Bycatch And Discards: Management INdicators, Trends and location] verkefnið var unnið af Matís í samstarfi við rannsóknastofnanir, HCMR, IFREMER, IMARES, Instituto Español de Oceanografía (IEO), CEFAS, Innovative Fisheries Management (IFM) og DTU-Aqua, frá sex löndum innan Evrópu. Verkefnið var styrkt af MariFish og Tækniþróunarsjóði Rannís.

Meginmarkmið verkefnisins var að afla þekkingar um brottkastsmynstur í Evrópu og meta skilvirkni aðgerða gegn brottkost. Einnig að bæta aðferðir til að meta og stjórna meðafla og brottkasti. Verkefnið notaðist við gögn um brottkast og afla innan Evrópu auk niðurstaðna úr viðtölum sem tekin voru við hagsmunaaðila.

Helstu niðurstöður verkefnisins voru að brottkast mynstur er mjög mismunandi eftir löndum, veiðarfærum, tegundum og veiðasvæðum. Mikilvægt er að regluverk á hverjum stað taki tillit til þessa. Þá benda niðurstöður til þess að hvatar til brottkasts séu margbrotnir og í sumum tilvikum geti reglugerðasetning beinlínis ýtt undir brottkast. Því er bent á mikilvægi þess að hugað sé að því að allir þættir reglugerða vinni saman gegn brottkasti, þegar slíkar eru settar.

Reykjavík, 15.11.2012

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Sveinn Margeirsson, verkefnisstjóri

October 2012

MariFish Final Report

Project Title (Acronym)
Bycatch And Discards: Management INdicators, Trends and locatiON **(BADMINTON)**

Project Duration:

Start date:	31/08/2009
End date:	30/09/2012

1.   Research Consortium Partners

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Applicant – Partner 5			
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Applicant – Partner 6			
Organisation	IFM (Innovative Fisheries management, Aalborg University)		
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Applicant – Partner 7			
Organisation	MATIS (Icelandic Food Research)		
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Applicant – Partner 8			
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2. Executive Summary

Project Title: Bycatch And Discards: Management INdicators, Trends and locatiON

Project Acronym: BADMINTON

Discarding keeps being an important issue in world fisheries; it is a way for fishers to adjust their landings to the legal and market constraints, but is largely considered as a waste of rare natural resources and as contributing to the depletion of stocks bearing a high fishing pressure. Many jurisdictions, including the European Commission, are preparing regulations to reduce or ban discards. To design effective regulations, an understanding of the extent and processes of the issue is required.

The MariFish BADMINTON project aimed to build up the knowledge of discarding patterns and factors in European fisheries, evaluate the efficacy of selective devices and other discard management measures that have been implemented in the past, and improve methods to analyse, monitor, and manage bycatch and discarding. Specific objectives included the provision of discard estimates for selected European fisheries, and of appropriate indicators; the determination of the most important factors affecting discard amounts and composition; and the elaboration of integrated management approaches to the discard issue.

BADMINTON relied on two types of approaches to fulfill these aims and objectives. First was the analysis of onboard observer data, since intensive collection of catch and discard data onboard commercial vessels has been undertaken in European countries under the European Union Data Collection Regulation (2002) followed and intensified by the Data Collection Framework (2008). Thus, one significant contribution of the project was to collate onboard observer data from several European Union member states, given the many differences between national onboard observer programmes sampling schemes, protocols, details of data recorded, and data storage formats. This first step paves the way towards a future better integration of national onboard observer programmes. The second approach was to conduct stakeholder interviews and expert consultation, which was meant to complement the data analyses with fishers perspectives on the discard issue, and to provide an integrated approach toward management.

Both approaches lead to the following two broad conclusions:

- Discard patterns exhibited high diversity across regions, countries, gear types, vessel sizes, and species, with variability being more pronounced among regions. Thus, discard management approaches might be devised at a regional level – consistent with the proposed regionalization of the currently discussed reform of the European Union Common Fisheries Policy.

- Discards amounts, patterns, and composition, are determined by a multitude of interacting natural and human (economic and social) factors in a given place and time, and usually no simple explanations can suffice. The latter affects the effectiveness of mitigation measures, and solutions are to be found down at a very detailed level such as the fishing operation, fishing trip, or vessel, which suggests that a bottom-up, or results-based approach seems to be the most advisable form to tackle the discards problem. Then, effective discard management strategies should be devised at various scales, from individual fishers implementation of

detailed species-, gear- and area-specific tools, to producer organizations, member states, regional levels, and the broad European Union.

The project has developed a number of tools, distinguished in three categories ie. selectivity related tools (including a modelling tool to estimate gear selectivity based on fish morphology, and preliminary indicators of fishing selectivity at the fleet and ecosystem scales), tools to appraise and understand the discarding issue in a given region, area or fishery (including modelling tools to establish catch and discard maps and devise spatial approaches to the management of discards, based on onboard observer data; a series of discard indicators embedded in a discard indicator dashboard, to monitor and manage the discards in a given fishery; a generic model to determine the relative importance of inferred discard drivers; a list of factors to be used in semi-structured stakeholder interviews, and interview methodology), and tools that can be used to assist in devising management strategies at various scales (including a framework to develop a fishery-specific mitigation strategy based on inferred drivers of discarding behaviour; a detailed evaluation of 12 discard mitigation measures, alone and in combination).

It should be underlined, however, that BADMINTON findings suggest that as discarding is in most cases an unavoidable consequence of a series of constraints on the fishing activities and production, managing discards implies taking account of the whole fishery management system. Hence, a discard management strategy should not include only a combination of discard mitigation measures; if discards are to be reduced, appropriate and consistent incentives need to be mended together.

3. Final Report

Project overview

Objectives and tasks

The project aimed at developing the knowledge of discarding patterns and factors in European fisheries, evaluate the efficacy of selective devices and other discard management measures that have been implemented in the past, and improve methods to analyse, monitor, and manage bycatch and discarding in European fisheries. Specific objectives included the provision of discard estimates for selected European fisheries, and of appropriate indicators; the determination of the most important factors affecting discard amounts and composition; and the elaboration of integrated management approaches to the discard issue.

Methods and results obtained so far

The project relied on two types of approaches to fulfill these aims and objectives. First was the quantitative analysis of onboard observer data, since intensive collection of catch and discard data onboard commercial vessels has been undertaken in European countries under the European Union Data Collection Regulation (2002) followed and intensified by the Data Collection Framework (2008). In 2009 the amount of data already accumulated was significant, but there was a gap in systematic analyses of the patterns in these data, which the project has started to fill. Onboard observer data, despite several well-known shortcomings including their high cost and unavoidable biases, have proven an invaluable source of information. Properly analysed, these data are appropriate to answer the questions initially asked by the project – quantifying amounts, with an estimate of the associated uncertainty; calculating indicators; and analysing the main factors for discarding, especially the efficacy of mitigation measures, the implementation of which can be monitored with this kind of programme. One significant contribution of the project was to collate onboard observer data from several European Union member states. This was far from obvious given the many differences between national onboard observer programmes sampling schemes, protocols, details of data recorded, and data storage formats. Several contributions have been based on collated international data. This first step paves the way towards a improved integration of national onboard observer programmes in the future – which will be necessary because in some areas, fleets from several countries interact.

However, given the complexity of the issue, and the fact that discarding is ultimately the outcome of human behaviours, a complete understanding cannot be achieved only based on empirical analysis of catch data – even if the data are extensive and the anlayses sound. Therefore the second approach used in the Badminton project to address these questions were stakeholder interviews and expert consultation. This was meant to complement the quantitative data analyses with qualitative fishers perspectives on the discard issue, and to provide an integrated approach toward management.

Main preliminary conclusions

Both approaches lead to the same, two broad conclusions.

1. We have found a wide diversity of discard patterns across regions, countries, gear types, vessel sizes, and species – also depending on whether a species is a target or a bycatch in a given fishery. It seems that variability was highest among regions, suggesting that discard management approaches might be devised at a regional scale – consistent with the proposed regionalization of the currently discussed reform of the European Union Common Fisheries Policy.

2. Discards amounts, patterns, and composition, are determined by a multitude of factors, including a strong influence of the current EU Common Fisheries Polilcy regulations – from quotas to minimum landing sizes and catch composition regulations. Several factors intervene in determining discards of a given species in a given fishery – and the diversity of combinations is on the same magnitude as the diversity of discard patterns. Moreover, these factors interact with each other to determine what is discarded. For example, favourable environmental conditions leading to a strong year class interact with quota and catch composition regulations and might result in high levels of discarding. This also affects discard mitigation measures, including selective devices, which interact with many other factors, so that their efficacy is often difficult to demonstrate, and in some instances can be offset. Interviewed fishers also outlined that discarding is dictated by a combination of factors – no simple explanation can suffice.

These conclusions are detailed and discussed below by work package.

▪ **The expected benefits and usability of results**

Overall these conclusions lead us to the following recommendations if discards were to be managed in the European Union fisheries. Since several factors determine discarding patterns in combination, and these factors vary widely across regions, gears, time and place, and species, no single management measure is going to address the issue. Rather, combinations of measures – which we may call discard management strategies – should be devised at various scales, from the broad European Union to the regional, member states, producer organizations and individual fishers implementation of detailed species-, gear- and area-specific tools. The project has developed a number of tools, listed below, that can be used at various scales to assist in devising these management strategies. A very important point is that a discard management strategy does not include only discard mitigation measures. Rather, discarding must be seen as a sometimes unavoidable consequence of a series of constraints on the fishing activities and production, including the network of regulations. Therefore, managing discards implies taking account of the whole fishery management system, and cannot be added on the top of a set of regulations that may themselves entail strong incentives to discard. In other words, appropriate and consistent incentives need to be mended together if discards are to be reduced.

▪ **Possible implication for stakeholders and policy**

Because discarding is the outcome of the interaction of many natural and human (economic and social) factors in a given place and time, it is very likely that solutions are to be found down at a very detailed level such as the fishing operation, fishing trip, or vessel. Therefore,

although fisheries management agencies (including the European Union) might be willing to set broad objectives towards discard reduction or elimination, it is most likely that the practical solutions have to be found and implemented by the actors themselves. A bottom-up, or results-based approach seems to be the most advisable form of discard management.

▪ **Tools developed in the project and available to devise discard management strategies at various scales**

Selectivity related tools:

- A modelling tool to estimate gear selectivity based on fish morphology
- Preliminary indicators of fishing selectivity at the fleet and ecosystem scales

Tools to appraise and understand the discarding issue in a given region, area or fishery

- Modelling tools to establish catch and discard maps and devise spatial approaches to the management of discards, based on onboard observer data
- A series of discard indicators embedded in a discard indicator dashboard, to monitor and manage the discards in a given fishery – the concept and methodology to estimate and present these indicators based on onboard observer data have been developed and demonstrated on a short list of case studies
- A generic model to determine the relative importance of inferred discard drivers
- A list of factors to be used in semi-structured stakeholder interviews, and interview methodology

Tools to devise discard mitigation strategies at various scales

- A framework to develop a fishery-specific mitigation strategy based on inferred drivers of discarding behaviour
- A detailed evaluation of 12 discard mitigation measures, alone and in combination

Acknowledgements

WP 1 Descriptive analysis of discards and total catch in European waters

Objectives and tasks

The objective of WP1 was to provide 1) a descriptive analysis of total catch and discards in terms of species and size composition for each metier, based on data collected onboard EU vessels under the Data Collection Regulation/Framework (DCR/DCF) and 2) to carry out a statistical analysis of spatial and temporal patterns in discards by the fleets and in fishing regions of the contributing member states.

Methods and results obtained so far

In **task 1.1** of WP1, a description of the observed species and size compositions of commonly discarded species and their associated landings was compiled by country, metier and fishing region (see WP1 data report). In total, data of 147 commercially-valuable fish and 26 invertebrate species were compiled from 19 different metiers and 11 major fishing grounds. Depending on where fishing was taking place, discards may be comprised of different species, either because of the different area and/or because of the different gear and fishing practices and/or different regulations. From a number of metiers and fishing regions, some of the most-frequently discarded species included: European hake (*Merluccius merluccius*) and mackerel (*Trachurus trachurus*); common dab (*Limanda limanda*); and European plaice (*Pleuronectes platessa*). For a number of national fisheries, despite the commonality of using the same gear, the fished areas were spatially segregated.

Based on this compilation of discard data, a manuscript of a *peer-reviewed paper on general patterns and contrasts (including some precision estimates) of discard estimates across a number of European metiers/fleets* has been submitted for publication (see Appendix D1.1). This manuscript presents a synthesis of both sampling effort and landings and discard rates of quota- and minimum-landing-size (MLS) regulated species that were also mentioned in the recent discard ban proposal by the European Commission. Discard rates were expressed as numbers of discards per unit of fishing effort ('DPUE'). Discard rates were combined across observer-based data from six different countries, 15 active-gear fisheries and 11 major European fishing regions spanning from the Baltic to the Mediterranean Seas (see Appendix D1.1). To determine whether discard rates differed the most between gear types or regions, comparisons were made between the coefficients of variation of discard rates across gear types for a given region and across regions for a given gear type. Discard rates were more homogenous across gear types than regions, suggesting that discard management strategies may be devised first at a regional level – potentially allowing variants between gear types and species within regions; which contrasts to the currently-proposed species-by-species approach by the European Commission (Article 15 of the Proposal for a regulation of the European Parliament and of the Council on the Common Fisheries Policy). Furthermore, a stark contrast was observed between discard rates in the Mediterranean with some other, more Northern, fishing regions. This may be related to smaller MLS, a quota-independent management system and lack of MLS compliance. It can be concluded that these species-, fisheries- and region-specific patterns need to be considered when setting meaningful catch quotas in support of the proposed discard ban regulation.

In **task 1.2** of WP1, absolute estimates of total catch and discard quantities by species for the different fleets and areas and the associated estimation of uncertainties were not obtained due to national regulations which precluded sharing of detailed commercial catch data.

To address objective 2 of WP1, a statistical technique was developed to estimate the spatiotemporal distribution of juvenile discard-sized European plaice (*Pleuronectes platessa*) as a function of space and time, gear used, sampling method (fisheries independent or -dependent) and some other relevant variables. These results were published as part of a peer-reviewed article on the statistical framework for estimating spatial and temporal discard patterns from sparse data (see Appendix D1.2). Observations of discarded numbers-at-age from stratified annual observer trips onboard commercial beam-trawl vessels (ranging between 10 and 20 per year) were combined with those from annual design-based beam-trawl

surveys. A flexible framework was built using generalised additive mixed models to formulate predictive functions. This work illustrated, for example, how immature plaice gradually migrate from their coastal nursery areas westwards into deeper North Sea waters. This process occurred increasingly at an earlier age in their life between 2000 and 2006.

This framework can be readily extended to other species such as cod. A manuscript about the spatiotemporal variability of North Sea cod discards is about to be submitted for publication. To elucidate the discarding patterns of cod in the North Sea, generalized additive mixed models (GAMMs) were developed for discard data from 11370 fishing events collected throughout the period 2003 – 2010. Data were collected across seven European Union (EU) Member States as part of the EU Data Collection Framework (DCF). The variability in discards that occurs as a result of depth, gear and its associated mesh size, and vessel specific characteristics were quantified. Discards less than and greater than minimum landing size MLS (small and large cod respectively) were analysed separately. The discard data defined above is collected by different segments of the fishing fleets. Hence, such data alone cannot define whether heterogeneity in discard rates results from fishing fleet characteristics (e.g. gear type and mesh size) or whether it is the result of spatiotemporal patterns in cod distribution. Therefore, data from the biannual international bottom trawl survey (IBTS) are used to complement the discard data.

Analyses revealed highly significant spatiotemporal heterogeneity among small (<MLS) and large (≥MLS) cod throughout the North Sea on both inter-annual and season time scales (Fig 1). Our analyses also revealed depth, time, location, gear type and mesh size, as well as individual vessel characteristics, to be correlated with discard rates of cod (Fig. 2).
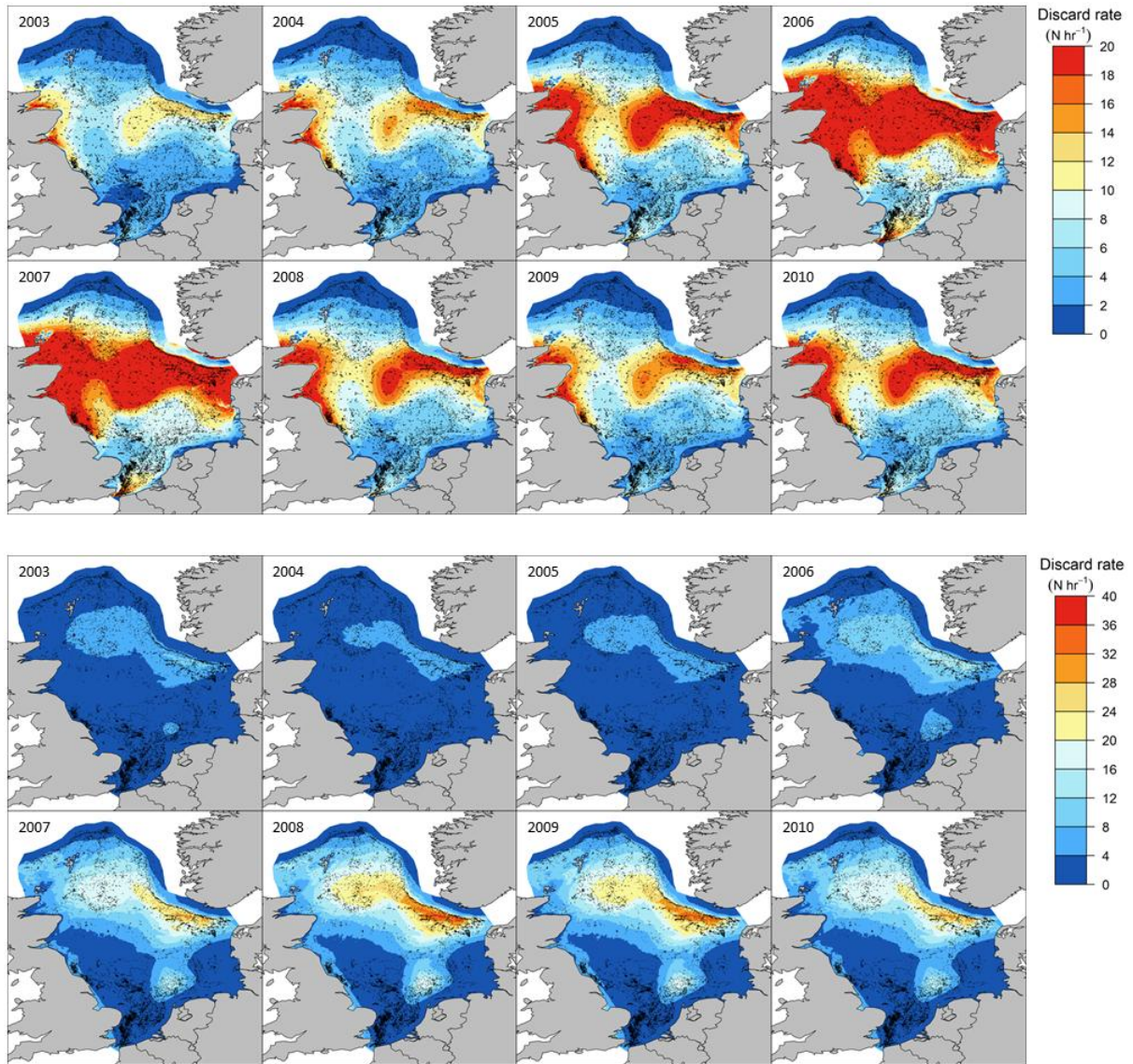
Figure 1. Model predicted densities of small (upper panel) and large (lower panel) cod discards in North Sea 2003-2010.
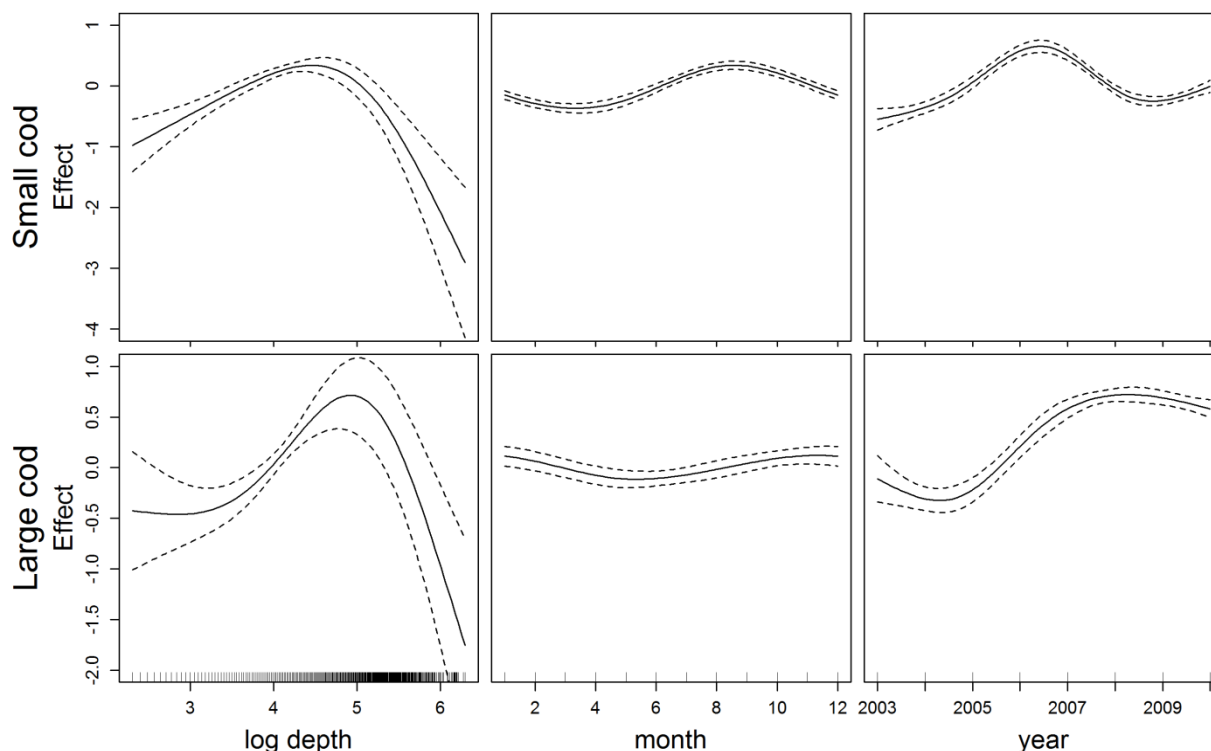
Figure 2. Model predicted effects of significant smoothing functions (solid lines) on the discard rates of small (top) and large (bottom) cod in the North Sea, 2003 – 2010. Dotted lines represent the 95% confidence limits. Vertical bars along the x-axis indicate observational values.

Discussion of the results and their reliability

Collating discard data from different fisheries and national sampling programmes can be difficult, because of simple regional differences in when and where fishers go fishing and whether or not they can take an observer on board, or how catches can best be sampled onboard despite space and weather constraints. All of the results of WP1 are based on data collected as part of nationally-adopted onboard observer programmes. In all European member states, cooperative sampling takes place where a Community vessel operator consents the boarding of an observer. All the sampling programmes considered here have similar sources of bias. Such, generally underestimating, bias may be associated with the selection of vessels on a voluntary basis, deployment of observers, and their sampling procedures. Deployment and observer bias are inherent to sampling programmes and difficult, if not impossible, to quantify. However, some of the sampling programmes used in this study were evaluated based on surrogate measures, such as comparing the relative biomass of marketable fish between observed and unobserved trips gleaned from logbooks, the representativeness of sampled trips versus total effort in time and space, or selecting vessels for sampling from randomly-generated lists and where sampling effort was allocated in proportion to the fisheries' annual fishing effort in the preceding year. The degree of bias caused by each source might vary between member states, owing to differences in the organization of the national onboard observer sampling programme, and the commitments of the fishers. Despite these shortcomings, on-board observer programmes remain the most complete source of information on all components of the catch by fishing vessels.

Main preliminary conclusions, including:

▪ **Benefit and usability of the results**

  • The benefit of the deliverable developed under **task 1.1**: it provides a comprehensive overview of species-, fisheries- and region-specific discard patterns throughout Europe.

  • The benefit of the framework and deliverable developed under **task 2.1** is that it can readily be extended to other species and/or research questions. For example, evaluating the effects of real-time area closures and fishing effort reallocations to predicted total numbers of plaice discards-at-age (work in progress in another EU-funded project). Similarly, understanding the spatiotemporal distribution of small and large cod discards throughout the entire North Sea shows that clear seasonal and inter-annual changes have taken place.

▪ **Implication for stakeholders and policy:**

  • The implications of the deliverable developed under **task 1.1**: region-, gear-type- and species -specific patterns need to be considered when setting meaningful catch quotas in support of the proposed discard regulation. A three-tier approach to discard mitigation is advisable, but since patterns contrast the most between regions, different regional strategies might be more efficient to address different issues in different settings.

  • Knowledge of the spatiotemporal distribution of discards provides valuable information for management. The plaice model predicted that in recent years, juvenile plaice have become more abundant in deeper, offshore waters. If these discards were to be avoided, spatial management measures need to be considered for these areas. The mortality of cod imposed by discarding could be reduced by defining areas where the use of more selective fishing methods are mandatory and ensuring that vessels catching cod have sufficient quota to land it. Now that the method is available, similar analyses can be developed for other species and places – provided sufficient onboard observer samples are available.

  • A ban on discards will likely face economic, regulatory, and political hurdles. Under a discard ban several issues emerge including: i) How to minimise the capture of juveniles and large fish for which there is no quota under a discard ban; ii) How to ensure discarding does not take place. The success of a discard ban will depend critically on complementary management measures addressing these issues.

Dissemination of the results

▪ **Peer-reviewed publications:**

Damalas, D. & V. Vassilopoulou, 2011. Chondrichthyan by-catch and discards in the demersal trawl fishery of the central Aegean Sea (Eastern Mediterranean). *Fisheries Research*, 108: 142–152

Feekings, J., Poos, J.J., Aarts, G., Madsen, N., van Helmond, A.T.M., Catchpole, T., Rochet, M.-J., Pout, P., Ulleweit, J., Vandemaele, S., Ulrich, C., Kempf, A. 2012: Spatiotemporal variability of North Sea cod discards. *In preparation*.

Poos, J. J., Aarts, G., Vandemaele, S., Willems, W., Bolle, L. J., van Helmond, A. T. M. in press. Estimating spatial and temporal variability of juvenile North Sea plaice from opportunistic data. *Journal of Sea Research*, doi: 10.1016/j.seares.2012.05.014.

Uhlmann, S. S., van Helmond, A. T. M., Kemp Stefánsdóttir, E., Sigurðardóttir, S., Haralabous, J., Bellido, J. Mª, Carbonell, A., Catchpole, T., Damalas, D., Fauconnet, L., Feekings, J., Garcia, T., Madsen, N., Mallold, S. Margeirsson, S., Palialexis, A., Readdy, L., Valeiras, J., Vassilopoulou, V., Rochet, M.-J. submitted: Discarded fish in European waters: general patterns and contrasts. *ICES Journal of Marine Science*.

▪ **Reports**

Helmond, A. T. M., Uhlmann, S. S. (eds). 2011: Work package 1: Report on an overview of existing discard data by métier, area, and member state. MariFish, London. 300 pp.

▪ **Conference presentations and seminars**

Feekings, J., Poos, J.J., Aarts, G., Madsen, N., Helmond, A.T.M., Catchpole, T., Rochet, M.-J., Pout, P., Ulleweit, J., Vandemaele, S., Ulrich, C., Kempf, A. 2012: Spatiotemporal variability of North Sea cod discards. ICES CM 2012/ C:31. ICES Annual Science Conference. 17-21 September 2012, Bergen.

Palialexis, A., Vassilopoulou, V., 2012. The local character of trammel net fisheries in Greece and the need of regional spatial approach for management effectiveness. 6th WFC, Edinburgh 7-11 May 2012.

Poos, J. J., Aarts, G. 2010. Progress working report: BADMINTON spatial modeling workshop: 19-21 May 2010, Ijmuiden.

Van Helmond, A. T. M., Uhlmann, S. S. 2012. Progress working report: BADMINTON and WP1 results. September 3, 2012, Rijswijk.

The key results were communicated to representatives of the Dutch Ministry of Economic Affairs, Agriculture and Innovation and the fishing industry during a meeting on September 3, 2012.

WP2 Indicators of bycatch and discards in European waters

Objectives and tasks

Development of indicators to monitor and manage discard issues for European fisheries/fleets:

1. State indicators describing the characteristics of discards,

2. Pressure indicators related to the selectivity of fleets and gears.

Methods used and Results obtained so far

The main outputs of this WP are an indicator dashboard that presents catch and discard estimates in major European fleets, their trends, and most likely cause, and a manuscript describing the methodology underlying the dashboard (see Appendix D2.1). Below we show an overview of the dashboard and an example case-study. Also a summary on a first attempt to develop pressure metrics describing fishing selectivity is provided.

- **A discard indicator dashboard**

The dashboard presents trends in catch and discard estimates for specific métiers obtained from sampling programmes onboard commercial fishing vessels. These samples have been extrapolated (knowing e.g. the total number of fishing trips) to estimate what happens at the fleet level. Because fishing activities and discarding behaviours are variable, the resulting estimates bear uncertainty – reason why the indicators are reported with confidence intervals (CI). The CI of e.g. a discard amount is a range of values likely to include the true (unknown) amount with a given confidence level (here 95%). The wider the CI, the more uncertain the estimate.

For each fleet, the dashboard provides an estimate of total catch and percent discarded with their CIs, the species composition of total catch, and percent discarded for the main species. Changes over recent years in amount (weight or numbers) and percent discarded for all species pooled, and a set of selected species, are shown. When unidirectional changes happened, their potential causes are investigated by interpreting the combined changes. For example, if discard amount increased while percent discarded did not change, a plausible cause is an increase in catch (see interpretation table); if there is evidence from the data that catch indeed increased, it is reported as a likely cause. If amount and percent discarded both increased, it may be that smaller fish were caught, of which evidence is sought in an index of catch length (the 5th percentile of the length distribution in the catch, $QL_{0.05}$). In the absence of such evidence, it is inferred that there was a change in sorting behaviour. The length distribution in the catch is also shown for the selected species.

Interpretation table	Discard amount ⬈	Discard amount ⇔	Discard amount ⬊
% discarded ⬈	Smaller fish caught $QL_{0.05}$ ⬊	Catch ⬊	Catch ⬊ & $QL_{0.05}$ ⬈
% discarded ⇔	Catch ⬈	No change	Catch ⬊
% discarded ⬊	Catch ⬈ & $QL_{0.05}$ ⬊	Catch ⬈	Larger fish caught $QL_{0.05}$ ⬈

Key to the trend figures. Vertical bars are confidence intervals. Lines show the most likely trends – i.e. unidirectional changes that best fit the data. Two lines are drawn when two trends are equally likely. This happens when e.g. an indicator first increased, then decreased, or when CIs are wide, indicating high uncertainty. If no trend is represented, this means that all trends were equally likely.

Example case study: *Nephrops* trawlers in the Bay of Biscay

This fleet targets *Nephrops* in the Bay of Biscay, especially the Northern part (Figure 2.1) and is active whole year round, with a peak in spring and summer (Figure 2.2).

In 2011 this fleet caught an estimated 12,777 tonnes [8,4-17,2], of which 48.4% [44.8-81.8] were discarded on average. The overall weight discarded has increased over 2003-2005, although the fraction discarded did not show any trend, except for a drop in 2010 (Figure 2.3) – The decrease in overall discards might be partly explained by the lower catch weight since 2007 (Figure 2.4).

The catch is made up primarily of *Nephrops*, hake, and monkfish (Figure 2.5); target as well as bycatch species are discarded. *Nephrops* discards consist mostly of undersized individuals, but a part of the catch above the minimum landing size is also discarded, either because they are soft, or to fetch a better market price with larger individuals (Figure 2.6a). *Nephrops* discards decreased since 2006 (Figure 2.6b), as did the proportion of *Nephrops* discarded – on average 40% of *Nephrops* catch is discarded (Figure 2.6b). The decrease in discards is probably explained by the deployment of selective devices, mandatory in this fishery since 2008. Hake discards consist mostly of small-sized individuals (recruits: Figure 2.7); they tended to decrease over 2003-2011 (Figure 2.8), since the proportion of hake catch discarded decreased, especially after 2006, from over 60% to around 40% (Figure 2.8). This decrease in discards, which was not accompanied by a decrease in catch, is probably a consequence of the square mesh panel designed to avoid catching small hake, mandatory in this fishery since 2006. Undersized monkfish were also discarded, although in smaller proportions (Figure 2.9); monkfish discards increased over 2003-2011, which might be explained by the increased in catch and also in the proportion discarded in 2008 and 2009 (Figure 2.10). The proportion discarded remains low though, since this species has a high market value.
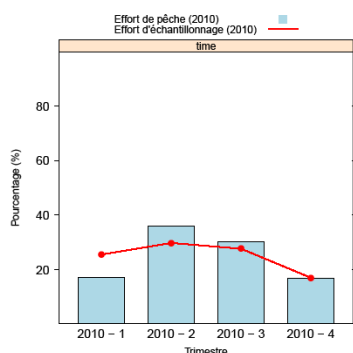
Figure 2.1. Temporal distribution of fishing activities (blue) and onboard samples (red), 2010.
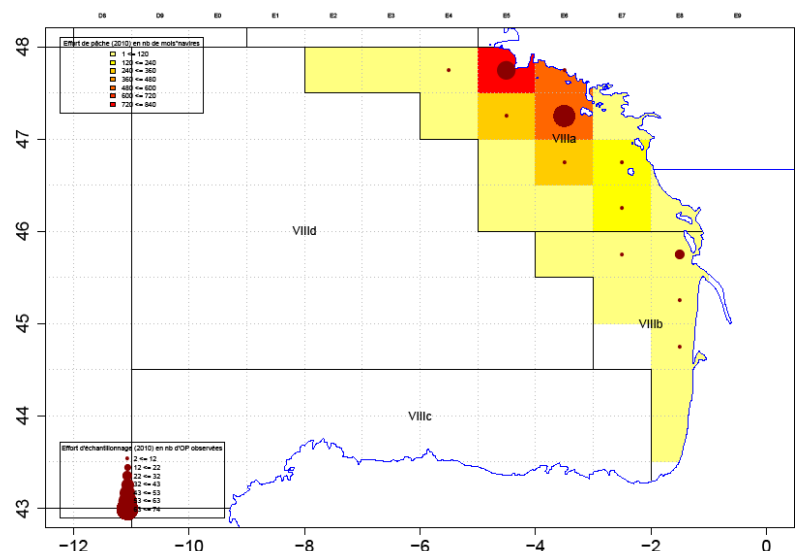
Figure 2.2. Spatial distribution of fishing activities (rectangle colour) and onboard samples (purple circles) in year 2010.
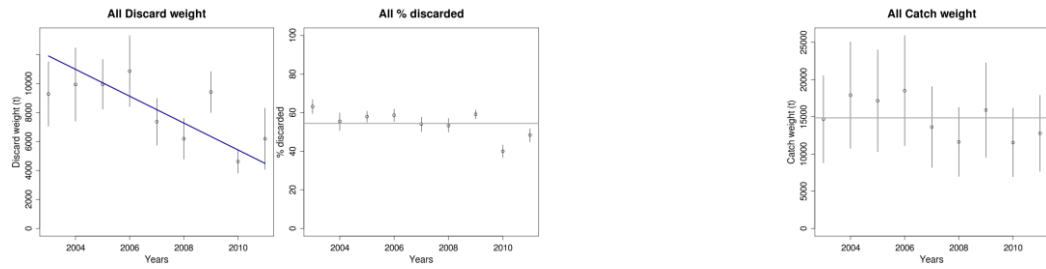
Figure 2.3. Total discard weight and discard rate (%) by *Nephrops* trawlers in the Bay of Biscay, 2003-2011. Vertical bars are confidence intervals.

Figure 2.4. Total catch weight by *Nephrops* trawlers in the Bay of Biscay, 2003-2011.
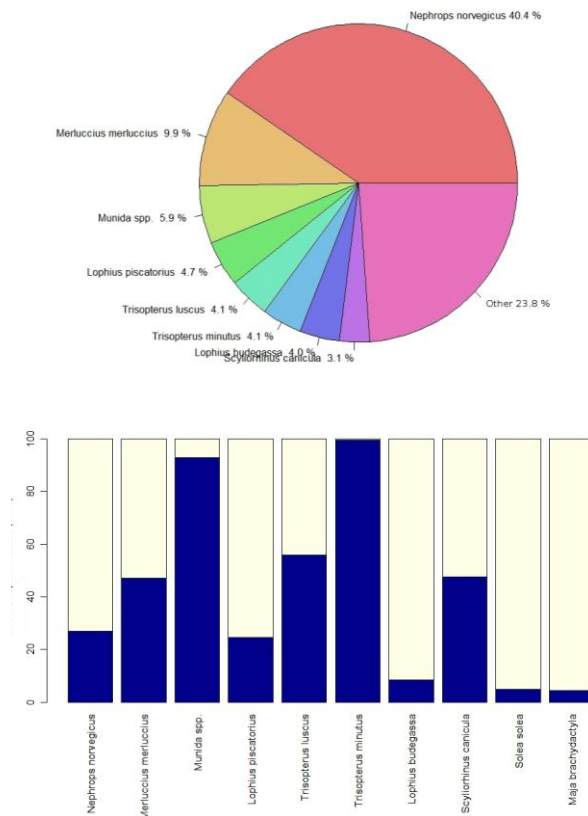
Figure 2.5. Catch species composition, and discarded proportion by species, by *Nephrops* trawlers in 2011 (by weight). Yellow landed, blue discarded.
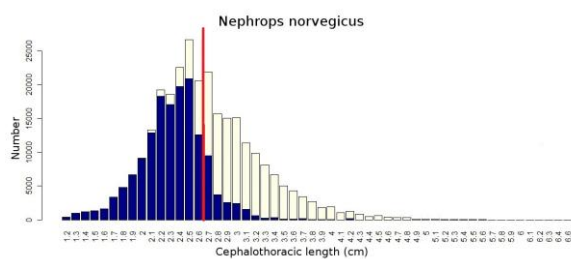
Figure 2.6a. Length composition of *Nephrops*
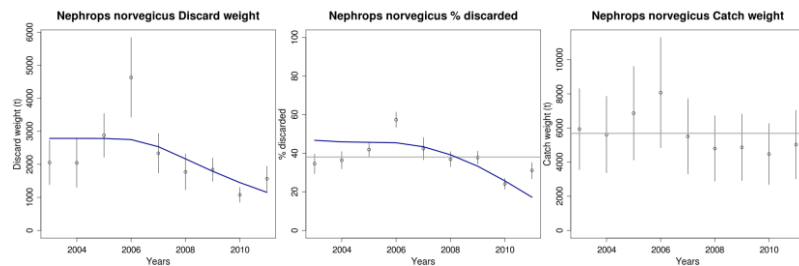
Figure 2.6b. *Nephrops* discard and catch weight, and 5th percentile of the

caught by *Nephrops* trawlers in 2011 (numbers). Yellow landed, blue discarded.

length distribution, for *Nephrops* trawlers in the Bay of Biscay, 2003-2011.
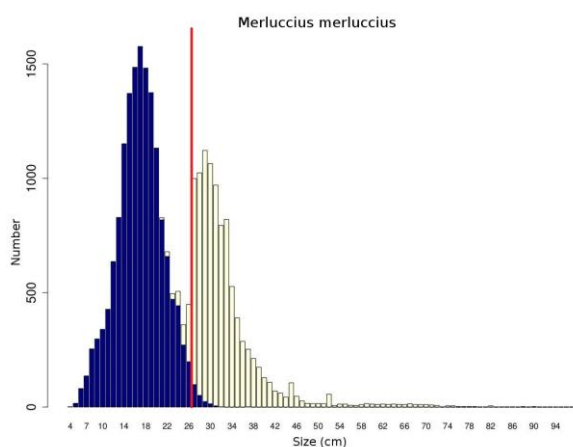
Figure 2.7. Length composition of hake caught by *Nephrops* trawlers in 2011 (numbers). Yellow landed, blue discarded.
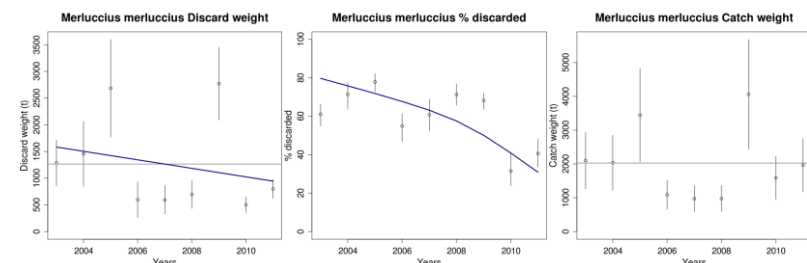
Figure 2.8. Hake discard weight and discard rate (%) by *Nephrops* trawlers in the Bay of Biscay, 2003-2011.
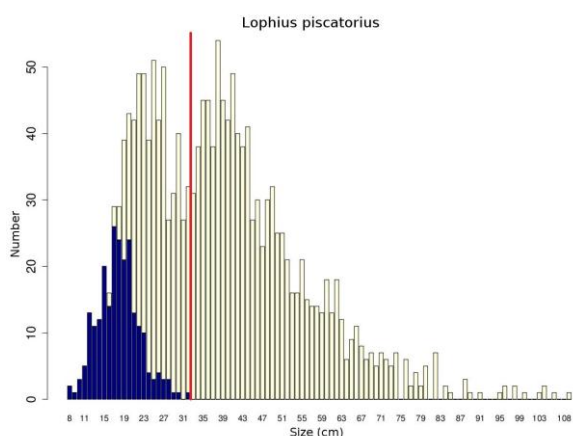
Figure 2.9. Length composition of monkfish caught by *Nephrops* trawlers in 2011 (numbers). Yellow landed, blue discarded.
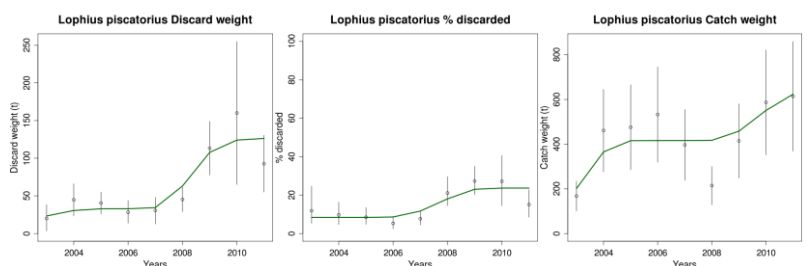
Figure 2.10. Monkfish discard and catch weight, and 5th percentile of the length distribution, for *Nephrops* trawlers in the Bay of Biscay, 2003-2011.

▪ **Fishing pressure indicators related to the selectivity of fleets**

This work aims at developing metrics describing fishing selectivity as the diversity of the catch – not just the amount of fishing pressure. At an ecosystem or fleet level, selectivity is more than just the selection curve of a species by a given gear – the proportion of the available fish that is taken in the gear, by length class. The higher level selectivity metrics need to describe which components are strongly / lightly / not at all affected by removals. A next question will be, how these more or less selective pressures impact the marine community and ecosystem.

A variety of data sources can contribute to this, however in most cases such data are currently lacking. In the frame of the project a pilot study was conducted using data from the French national onboard observer programme as a first attempt to characterize the pressures exerted by fisheries by providing catch composition by species and size for the whole catch, as well as

information on the fishing methods. Catch composition and length structures from French scientific survey data were used to characterize the state of marine communities, and compare with commercial catches. The case-study analysed is from the Southern Bay of Biscay, where a Southern site was considered more "selectively" fished than another one further North – that is, exploited by passive gears, generally believed to be more selective with respect to size and species than mobile gears. Several metrics of selectivity were calculated, including species richness and evenness in the catch, average length and length range in the catch, and discarded proportion by weight and number. Evidence contradicting the general thinking that passive gears are more selective than active gears was found. Relationships between the selected metrics were consistent, but richness and mean length resulted the most relevant metrics to detect differences in gear selectivity. Although the above was a pilot approach it could serve as reference to design future surveys contributing to an ecosystem perspective.

Discussion of the results and their reliability

▪   **A discard indicator dashboard**

The discard indicator dashboard provides a summary of key information to be considered for managing discards: amounts, composition, and trends over recent years. Unavoidably the reliability of results is limited owing to the high sampling uncertainty – many European onboard observer programmes have small sampled fractions compared to total fishing activity, and this activity is know to be very variable. But this limited reliability is presented in the discard indicator dashboard as confidence intervals, and the possibility to consider several, equally likely trends in indicators. So the users are informed of the uncertainty in the information provided.

Even short time trends are relevant for this kind of presentation, since discards fluctuate under the influence of many factors, some of which such as regulations or year-class strength on a very short term. Five or six to ten years seems to be the most appropriate length of a time series to present in such a dashboard.

The indicator selected as a length index, the 5th percentile of the length distribution in the catch, $QL_{0.05}$, did not prove very appropriate – it did not trend in a significant and intelligible way in any of the case studies. This may be because size is not always the first reason for discarding – many other factors could interfere with size selectivity of gears, even for stocks with a minimum landing size. Therefore a metric for another factor might be more appropriate to include among the first two causes analysed to explain trends in discards, along with total catch weight. The 5th percentile of the length distribution in the catch might also be a metric difficult to estimate from an onboard observer programme, if it fluctuates widely between hauls or trips.

▪   **Fishing pressure indicators related to the selectivity of fleets**

Very few metrics of fishing pressure at a fleet or ecosystem levels are available so far, and all describe the amount of fishing (fishing effort or total catch or average fishing mortality) rather than how it is distributed across ecosystem components. Therefore the first results are very promising. Among the commercial gears, important differences of selectivity were identified. Longlines appeared to be the most selective gear, among all gears taken into account in this study, with respect to species. However, the level of discard in both weight and number, was not significantly lower than for the other gears except bottom trawls. Even if a general pattern

tends to show that passive gears would be a little more selective than active gears, when considering the metrics of species-selectivity, especially richness, bottom trawls and trammel nets appear of similar selectivity. Similar results were found for gillnets and pelagic trawls. Those are evidence that contradict the general thinking that passive gears are more selective than active gears. A drawback of this approach is that it requires a large amount of data derived through targeted surveys. Onboard observer programmes were initially designed to estimate by-catch of the most commercially important species, while for acquiring data that can be used in an ecosystem perspective, appropriate sampling approaches are required.

Main conclusions

▪ **The expected benefits and usability of results**

The discard indicator dashboard can be used to inform discard management decisions, especially in the perspective of a discard reduction. The prototype can be adapted to each specific fishery or situation, provided appropriate onboard observer data are available. Other factors, such as abundance indices from scientific surveys, could be included in the analysis – the method is easy to expand.

Fishing pressure metrics describing on which component the fisheries exert the heaviest burden are going to be useful in developing an ecosystem approach to fisheries management. These metrics of high level pressure do not describe just how much is fished, but also how it is fished.

▪ **Possible implication for stakeholders and policy**

Stakeholders could use the dashboard as well as fisheries managers, especially in a framework of bottom-up discard management. For example, most of the figures developed in the dashboard are currently included in the report on the French onboard observer programme delivered to the French fishers organizations – and they use it for various purposes, including negotiating / adapting to the reform of the Common Fisheries Policy under discussion.

In the future, tools to better understand and manage the pressures exerted by various fishing fleets on marine ecosystem components are a potential consequence of the current developments.

▪ **Possible recommendations for future work**

As for the discard indicator dashboard, procedures and tools to easily incorporate different and/or more factors in the analysis need to be developed and made available.

Fishing pressure indicators need to be combined across gears interacting in a given area. Then, how the selectivity (or diversity) of the pressure affects the marine ecosystems will be examined – appropriate impact metrics need to be developed for this, such as the species or length diversity in the marine community, or metrics describing the size spectrum.

Dissemination of the results

Dubé, B., Diméet, J., Rochet, M. J., Tétard, A., Gaudou, O., Messanot, C., Biseau, A., and Salaün, M. 2012. Observations à bord des navires de pêche professionnelle. Bilan de l'échantillonnage 2011. 283 pp.

Fauconnet, L., Badts, V., Biseau, A., Diméet, J., Dintheer, C., Dubé, B., Gaudou, O., Lorance, P., Messanot, C., Nikolic, N., Péronnet, I., Reecht, Y., Rochet, M. J., and Tétard, A. 2011. Observations à bord des navires de pêche. Bilan de l'échantillonnage 2010. 192 pp. http://archimer.ifremer.fr/doc/ 00054/16490/

Fauconnet, L., Rochet, M. J., Trenkel, V. M., Morandeau, G., and Caill-Milly, N. 2012. Selective or less selective: what can data tell us about fishing pressure on marine communities from the Southern Bay of Biscay. Pages 14. ICES CM 2012/C:08.

Rochet, M. J., Bellido, J. M., Burny, C., Catchpole, T. L., Condie, H., Fauconnet, L., Feekings, J., Madsen, N., Mendoza, M., Palialexis, A., and Vassilopoulou, C. 2012. What do European fleets discard? Prototype of an indicator dashboard based on onboard observer data.

Carbonell, A., A. Mir, T. García, X. Valeiras, V. Rubio, E. Olafsson, M. Gonzalez, B. Guijarro, N. Pérez and JM. Bellido, 2012. Spatial and temporal variability of discards indicators and fishery factors affecting the otter trawl fishery in the Spanish Mediterranean Sea. ICES CM 2012/ C:23. ICES Annual Science Conference. 17-21 September 2012, Bergen.

Bellido JM., M. Mendoza, J. Valeiras, T. Garcia, N. Pérez, S. Mallol, R. Goñi, and A. Carbonell, 2012. Pressure indicators describing bycatch and discards in selected Spanish fisheries ICES CM 2012/ C:25. ICES Annual Science Conference. 17-21 September 2012, Bergen.

Santos, J., I. Salinas, F. Velasco, JM. Bellido and Nélida Pérez, 2012. Potential role of blue whiting exploitation patterns in the success of improving hake selectivity in Spanish Atlantic coastal OTB mixed fisheries ICES CM 2012/ C:27. ICES Annual Science Conference. 17-21 September 2012, Bergen.

WP3 Factors affecting discard patterns

Objectives and tasks

The two objectives for WP3 were completed:

1) An analysis of the environmental and technical factors that influence discard patterns.

2) An evaluation of the efficacy of technical measures at the fleet level

Many environmental and vessel/gear specific parameters influence discard rates. These factors vary between species, vessels and metiers, over time and space. Understanding the factors that determine what and how much is discarded is key if we are to propose mitigation tools for fisheries management. There is especially a need to investigate the effectiveness of mitigation tools that have been implemented in the past, primarily technical regulations,

including gear modification. Selected fisheries and species were investigated to assess the relative effects of fishing practices and environmental factors on discard patterns.

Methods used and Results obtained so far, including statistical analysis (if appropriate)

Modelling tools were developed in workshops for Badminton (IMARES) and the ICES Workshop on Ecosystem Indicators of Discarding (WKEID) and independently by project partners. These were used to identify the main drivers of discarding and investigate their influence on the relative effects of environmental and technical factors on discarding patterns. Data including spatial data (latitude and longitude, ICES statistical rectangle, ICES sub area and area) and temporal information (hauls times and dates, month, year) were used as variables in the analyses alongside length data of retained and discarded fish from the observer programmes. Supplementary data on minimum landing sizes, recruitment strength, quota availability, market price, codend mesh sizes and selective devices were also used where available.

Six case study fisheries were investigated, Table 1. All case study fisheries included variables pertaining to technical measures (e.g. cod end mesh size, selective devices, catch composition regulations) and environmental variables (e.g. spatial, temporal, depth, juvenile abundance). All case studies utilised data from the respective observer programmes to determine estimates of discards (e.g. discard numbers per haul <MLS, weight of discards per trip). The required models and details of the formulae used had to be specific in each case study. This was due at least in part, to the data on technical and environmental variables that were available.

Alongside the case study investigations, a generic model was also developed which could be applied to data from all European observer programmes with some additional fundamental data on MLS and quota associations. The case studies used methods which could only be used for fisheries for which there was sufficient data and were specific to those fisheries, whereas the generic model was less exhaustive but could be applied to all species-gear-area combinations and data from all European observer programmes. The objective was to make inferences as to the drivers of discarding with the ability to determine the relative importance of those drivers at difference scales. As part of WP3, this model was applied to the entire dataset from the English observer programme and selected components of the observer programmes from France, Denmark, Greece and Spain.

Table 1. Description of model and variables analysed in each of the six case study fisheries for WP3.

Case study	Fishery	Model and variables
1	French *Nephrops* trawl fishery – Bay of Biscay	GAM – mesh size, ICES rectangle, year, quarter, selective device, days at sea, duration of fishing operation, water depth, temperature, vessel power
2	French otter trawl fisheries in Eastern Channel and North Sea	MLS, quota, catch composition
3	Danish otter trawl fishery - Baltic	GAMM - codend mesh/type, quarter, MLS, juvenile abundance, longitude and latitude, catch weight, haul, duration, vessel power, market price, vessel
4	Danish *Nephrops* trawl fishery - Kattegat	GAM - quarter, depth, latitude and longitude, mesh size range, juvenile abundance, catch weight,

| 5 | Danish otter trawl fishery (targeting plaice) – North Sea | GAM – mesh size range, longitude and latitude, quarter, juvenile abundance, haul duration |
| 6 | Greek otter trawl fishery | GAM – mesh size, year, month, fishing depth fish length, minimum catch size |

Discussion of preliminary results and their reliability

A summary of results are presented here for each case study, all case studies have an associated manuscript, the latest versions are provided (see Appendix D3.2a-f). Following the case study summaries is a description of the generic model which provides data on the relative importance of inferred drivers of discards (see Appendix D3.1).

▪ **Case study 1: Selective devices contributed to reduce discards in the *Nephrops* trawl fishery in the Bay of Biscay**

(Ifremer; see Appendix 3.2a)

Natacha Nikolic, Joël Dimeet, Spyros Fifas, Michèle Salaun, David Ravard, Laurence Fauconnet, Marie-Joëlle Rochet

The *Nephrops* fishery in the Bay of Biscay is an important commercial fishery which generates large amounts of discards owing to the use of small mesh trawls. To reduce discards, French trawlers were equipped with a variety of selective devices, from 2005 onwards. Here, we examine their efficacy using data from an onboard observer programme from 2003 to 2010.

A general additive model was built, including the main factors driving the variability in the discards, landings and catches of 11 species: *Nephrops*, hake, monkfish, horse mackerel, whiting, bib, dogfish, blue whiting, common dragonet, argentine, red bandfish. The results revealed the efficacy of the measures with *Nephrops*, hake, monkfish, horse mackerel, and whiting. The flexible grid decreased *Nephrops*, hake and monkfish discards, and the square-mesh panels decreased horse mackerel, whiting and hake discards. The 80 mm codend mesh size was also efficient to decrease the discards while increasing the landings. Other explanatory variables such as haul duration or gear type also influence discards, and could be used to further reduce discards. Overall, the technical regulations in the Bay of Biscay *Nephrops* trawler fishery seem to have been partly effective by reducing discard amounts and proportions.

Discards peaked in different quarters for each species – summer for *Nephrops*, winter for hake, and spring for whiting. Hake, monkfish, horse mackerel, whiting, and bib numbers caught, discarded, and/or landed varied significantly among years. The catch of all species varied significantly across ICES rectangles. Twin trawls generated more discards of hake, horse mackerel, and common pout than otter trawls. Days at sea significantly affected catches, with more hake and *Nephrops* discards on longer trips, but also more *Nephrops* landings. The duration of the fishing operation was also an important factor, with more discards of *Nephrops*, hake, horse mackerel and whiting from long hauls.

The dorsal square-mesh panel, meant to let juvenile hake escape, is indeed effective to reduce hake discards, and even increases hake landings. It was mandatory since 2005, and indeed, since it fulfilled its main purpose, it was taken up by all fishers from 2006. Among the three

devices meant to decrease *Nephrops* discards, only the 80 mm codend mesh size was found to actually decrease *Nephrops* (and hake) discards; the flexible grid only reduced hake discards, but also decreased *Nephrops* landings; and the ventral square mesh panel had no effect on the two main species, while it decreased whiting discards.
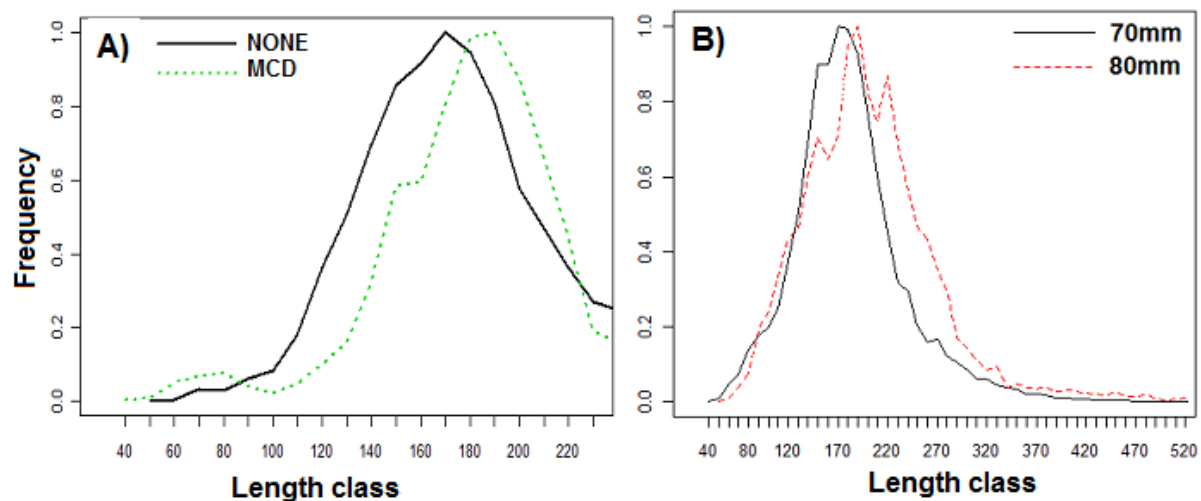
Figure 3.1. Frequency of length classes (mm) of hake catch (number of individuals) in the Bay of Biscay from 2003 to 2005 by trawlers equipped with (A) dorsal square panel (MCD) and without (NONE), and (B) codend mesh size at 70 mm and 80 mm.

▪ **Case study 2: Why are cods from the Eastern Channel and North Sea discarded?**

(Ifremer; see Appendix 3.2b)

L. Fauconnet, B. Dubé, Y. Vermard, A. Biseau

The objectives of this study were to understand the extent of cod discarding in the Eastern Channel and the North Sea, and to understand the main reasons for discarding, especially those due to management measures.

Observer data used to analyse the reasons for discarding. Several management tools and regulations exist that can lead to discarding. Among them, three were examined here : i) minimum landing size (MLS), ii) quota and, iii) technical measures regulations CE no. 850/1998 and CE no. 2056/2001 for additional measures specifically for cods.

High uncertainties were found on discard rates for cod, but differences both in space and time were highlighted by this analysis. Generally, we observed that cod contribution to the total catch and discard were very small. Both cod catch and discard rates decreased from 2009 to 2011.

In 2009 in the Eastern Channel, the French national quota was caught early in the year, and subsequently many producer organizations closed their quotas. Therefore in 2009 in the Eastern Channel, a high discard rate of cod was observed in the vessels from Boulogne-sur-Mer, 65% of the total discards were due to reached quota. By contrast, cod quotas could not be caught, neither in the North Sea in 2009, nor in 2010 and 2011 in both areas. Quotas were not responsible for discards in those areas/years. In 2009 in the North Sea, the regulation on catch composition was responsible for 48% of cod discards on vessels from Boulogne-sur-Mer. This percentage diminished in 2010 and there was no discards in 2011 due to this regulation. On the trawlers targeting saithe, cod bycatch was so small that the threshold was

never reached, therefore technical measures were not responsible for any discards. The percentage of "under-size" discards was more important in the North Sea than in Eastern Channel for vessels from Boulogne-sur-Mer. Discards of individuals above MLS decreased from 2009 to 2011.

- **Case study 3: The effect of regulation changes and influential factors on cod discards in the Baltic Sea demersal trawl fishery**

(DTU-Aqua; see Appendix 3.2c)

Jordan Feekings, Peter Lewy, Niels Madsen

Baltic Sea cod (*Gadus morhua*) stocks have declined 10 fold over the past 30 years which has subsequently led to numerous legislations and policies being introduced to improving the state of the stocks. The main objective of technical regulations within fisheries is to enhance the state of the stocks through improvements to gear selectivity, subsequently allowing young individuals to escape capture. A generalized additive mixed model was applied to analyse the relationship between discard rates, gear regulation changes, and a range of additional explanatory factors. Gear regulation changes enforced in the Danish Baltic demersal trawl fishery and other factors, namely minimum landings size, juvenile abundance, catch weight, price, and their spatial and temporal distribution were found to significantly affect discards rates. The newest and currently legislated gears were identified as having the lowest discard rates. The increase of minimum landing size from 35 to 38 cm has increased discard rate.

Generalised additive mixed models (GAMMs) were used to describe the relationship between the total numbers discarded per haul under and over MLS for the eastern and western Baltic cod stocks and a range of explanatory variables, and to account for the unbalanced sampling design between explanatory variables.

The seasonal effect on discards of cod was significant in three of the final models. Discards of cod over and under MLS in the eastern Baltic were significantly higher in quarter 2 than all other quarters. In the eastern Baltic, discards under MLS were lowest in the Bornholm Basin and increased in a north-easterly direction.
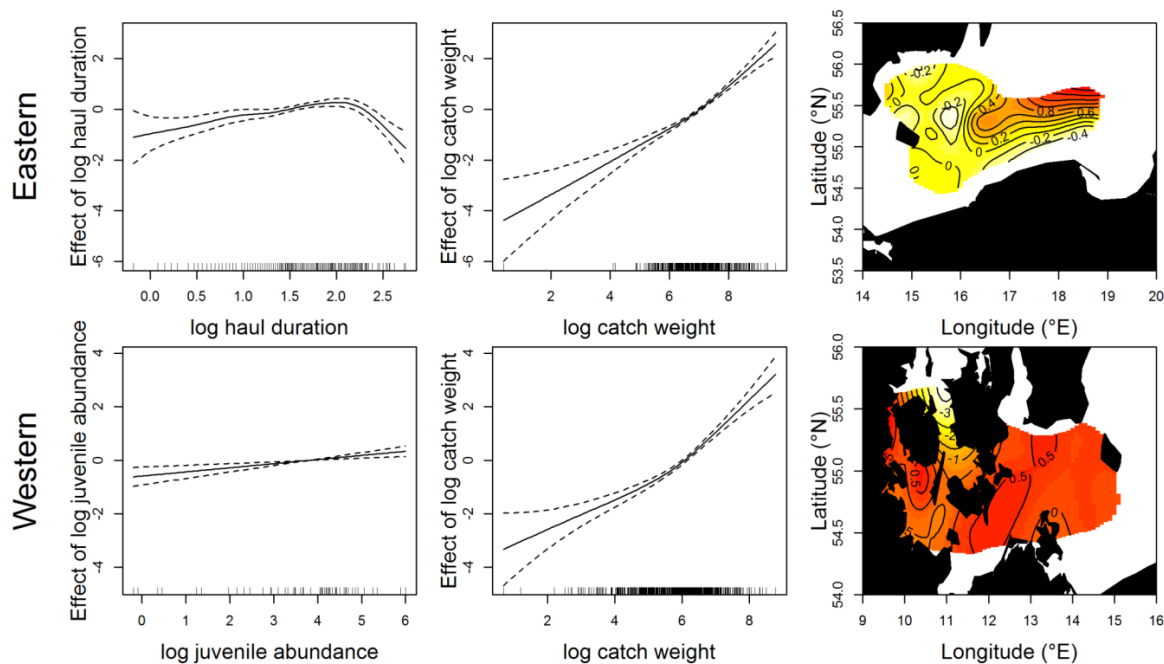
Figure 3.2. Model predicted effects of significant smoothing functions (solid lines) on the discard rates of cod greater than MLS in the Eastern (Top row) and Western (Bottom row) Baltic Sea 1997 – 2010. Dotted lines represent the 95% confidence limits. Vertical bars along the x-axis indicate observational values. The surface and contour lines describe the effect of the 2-d smoothing function on the geographical coordinates.

Despite the introduction of various technical measures in the form of codend mesh size increase, no significant reduction in discard rates during the first part of the period investigated was observed. This could be caused by several factors: i) non-compliance because of economic losses, as reported by Suuronen et al. (2007); ii) the improvements were too small to be detected by the models with the variability in the available data; iii) the increase in selectivity expected from scientific experiments is not present under commercial settings because the gears are rigged and fished differently. For the latest gears introduced in the period investigated (Bacoma 110 mm codend in the western Baltic, the New Bacoma 120 mm, and T90 120 mm) a significant effect on discard rates was observed., suggesting a significant overall reduction in discard rates for this period, although several other facets have been influential.

▪ **Case study 4: Fishery Discards: Factors Affecting their Variability within a Demersal Trawl Fishery**

(DTU-Aqua & Cefas; see Appendix 3.2d)

Published: Feekings J, Bartolino V, Madsen N, Catchpole T (2012) Fishery Discards: Factors Affecting Their Variability within a Demersal Trawl Fishery. PLoS ONE 7(4): e36409.

This case study examined the data collected within the Danish discard observer program to describe the factors that influence discarding within the Danish Kattegat demersal fleet over the period 1997 to 2008. Generalised additive models were used to assess how discards of the three main target species, Norway lobster, cod and plaice are influenced by important factors.

Our results show that discards are influenced by a range of factors that are different for each species and portion of discards.

In the Kattegat, the demersal trawl fishery, the focus of this study, is the dominant gear type, accounting for approximately 80% of all fishing effort. The fishery has been faced with regulatory measures for the recovery of the Kattegat cod, which has largely been unsuccessful so far. The small mesh sizes currently and previously employed in the Kattegat are used to retain Norway lobster (*Nephrops norvegicus*) and sole (*Solea solea*).

We apply a Generalised Additive Model (GAM) using discard data from the Danish discard observer programme for the demersal trawl fishery in the Kattegat to identify the driving factors that influence discarding practices.

Seasonal discarding was found to be an influential factor and can be attributed to the targeting behaviour of the fishermen and the condition/behaviour of species during different seasons. For example, it is observed that plaice ≥MLS are discarded more during the first quarter of the year. This can be attributed to the physical condition of plaice throughout the year. In winter and early spring large plaice are of low condition and watery flesh, resulting in lower market value. Norway lobster < and ≥MLS are discarded more during the summer when they are targeted the most, while cod in the Kattegat have traditionally been targeted during the first months of the year when higher densities occur due to spawning. High discarding of cod ≥MLS is also observed when quota utilisation is low. The spatial distribution of discards for the three species observed here were all different.

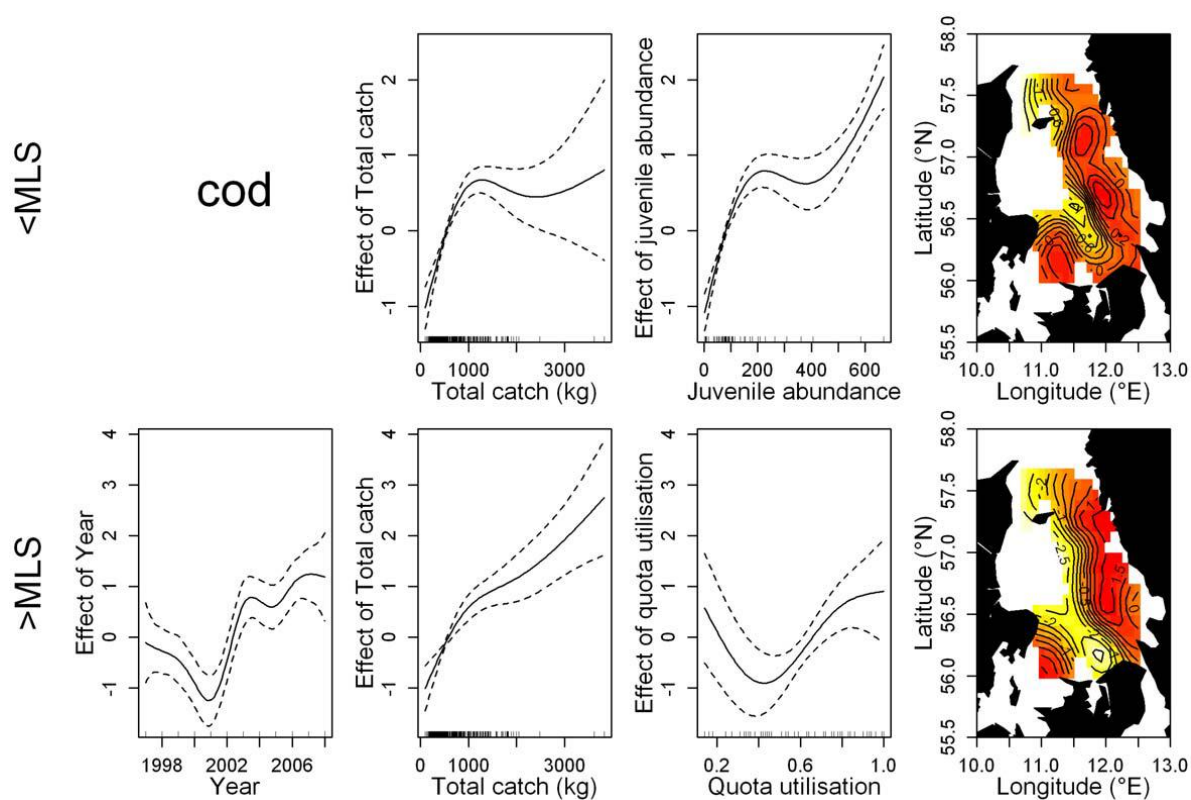**Figure 3.3**. Effect of the significant smoothing functions (solid line) on the discard rate of cod in the Kattegat demersal trawl fishery. Cod <MLS (top row) and ≥MLS (bottom row). Dotted lines represent the 95%

confidence limits. Vertical bars along the x-axis indicate observational values. The surface and contour lines describe the effect of 2-d smoothing function on the geographical coordinates.

▪ **Case study 5: Discarding of plaice (*Pleuronectes platessa*) in the Danish North Sea trawl fishery**

(DTU Aqua; see Appendix 3.2e)

The trawl fisheries are commercially the most important Danish fishery targeting plaice. Here we analysed discard data collected onboard Danish vessels in the period from 1998 to 2008. We describe the general patterns in these data by dividing them into three mesh size categories: 80-99 mm, 100-119 mm and ≥120 mm to reflect implemented technical measures of relevance. We analyse the landed and discarded portions in these mesh size categories and link the discarding to the minimum landing size. We employed a GAM model to assess how discarding of plaice below the minimum landing size is connected to relevant factors that could be of relevance from a management perspective. We identified a statistical significant effect of mesh size category and area.

There are several mesh size regulations in force, and today the use of meshes 80-99 mm is only allowed in the southern North Sea (South of 55ºN or 56ºN east of 5ºE) whereas the minimum mesh size in the North is 100 mm. The analysis suggests that mesh size is highly influential on the amounts and rates of plaice discarded. The discard rates in the ≥120 mm and 100-119 mm mesh size categories were significantly lower than the 80-99 mm mesh size category. However, the difference between the 100-119 mm and ≥120 mm mesh size categories was non-significant. The interaction between longitude and latitude on discard rates was also found to be highly significant. Discarding is highest in the area closest to the plaice box in the south east, and decreases with increasing distance.

The present analysis suggests that lowering the MLS by 2 cm would reduce about half of the discards in the ≥120 mm mesh size category, whereas 4 cm could potentially reduce discards by 54-86% for the three mesh size categories. Abandoning a MLS and avoiding fishing without having sufficient possibility to land plaice (eg. A move from landings quota to catch quota) seems to be a realistic option, especially if the goal is to eliminate discards completely.

▪ **Case study 6: Slack regulation compliance in the Mediterranean fisheries: a paradigm from the Greek Aegean Sea demersal trawl fishery, modelling discard ogives**

(HCMR; see Appendix D3.2f.)

Annual discard ogives were estimated using generalized additive models (GAMs) for seven demersal fish species (or taxa): bogue, *Boops boops* (Linnaeus), anglerfish, *Lophius spp.* (*L. budegassa* Spinola; *L. piscatorius* Linnaeus), European hake, *Merluccius merluccius* (Linnaeus), red and stripped red mullet, *Mullus spp.* (*M. barbatus* Linnaeus; *M. surmuletus* Linnaeus), common Pandora, *Pagellus erythrinus* (Linnaeus), horse and jack mackerels, *Trachurus spp.* (*T. picturatus* Bowdich; *T. mediterraneus* Steindachner; *T. trachurus* Linnaeus), and deep water rose shrimp, *Parapenaeus longirostris* (Lucas). The analysis was based on data collected on board commercial bottom trawlers in the central Aegean Sea from

1995 to 2008. Length of specimens and fishing depth (along with Year) were the variables that had the most profound effect on the proportion of fish discarded. Compliance to the established minimum catch size of marine organisms (MS) was very low, a fact attributed to the low selectivity of currently used mesh sizes, the market demand for undersized fish, as well as the low control and enforcement effort.

- **Generic model to determine relative importance of inferred discard drivers – using inferred drivers of discarding behaviour to develop a fishery specific mitigation framework**
(Cefas, DTU-Aqua, Ifremer, IEO, HMCR; see Appendix 3.1).

T. Catchpole, J.P. Feekings, N. Madsen, A. Palialexis, V. Vassilopoulou, N. Nikolic, M.J. Rochet, J.M. Bellido

The model was based on inferences made on the main causes of discarding by partitioning the discards into four categories based on the length at which the fish were discarded and the legislative restrictions associated with each species-area-gear combination. The first category included fish discarded below the MLS. The second category included fish discarded below a minimum marketable size (MMS) and species that have no market outlet (non-commercial species). The MMS was defined as the minimum length at which fish were landed. The third category describes fish with an associated quota which were discarded above the length normally landed. The inferred driver for these discards included one or more of, a response to quota restrictions, catch composition regulations, markets forces, inconsistent sorting, poor condition of the fish and/or damage to the fish. This category was defined as the maximum amount of discards that could be attributed to the fishers' response to quota restrictions. The fourth category of discards included species with no associated quota and discarded above either the MMS or MLS. These discards were all of commercial species; fish at the lengths discarded were landed by some fishers at least some of the time. The inferred reason for discarding these fish included inconsistencies in market opportunities, inconsistent sorting, catch composition regulations and poor condition of the fish and/or damage to the fish. This category was defined as the maximum amount of discards attributed to inconsistencies in sorting and in the marketing opportunities.

The proportionate contribution of the different categories was established for different area-gear-species combinations. For example, the model was used to determine the contribution to the total discarded volume of discards generated by the mismatch between gear selectivity and market opportunity (category one and two); the weight associated with the compliance with legal MLSs (category two) and the maximum weight associated with quota restrictions (category three). The model demonstrated that, with some rudimentary information on MLSs and the presence or absence of quota restrictions, the length information generated in European observer programmes can be used to infer the main drivers of discarding. With the application of these simple conditional functions the data can be interrogated at different scales to gain an understanding about the causes of discarding and the differences in the importance of those causes between fisheries, gears, areas and species.
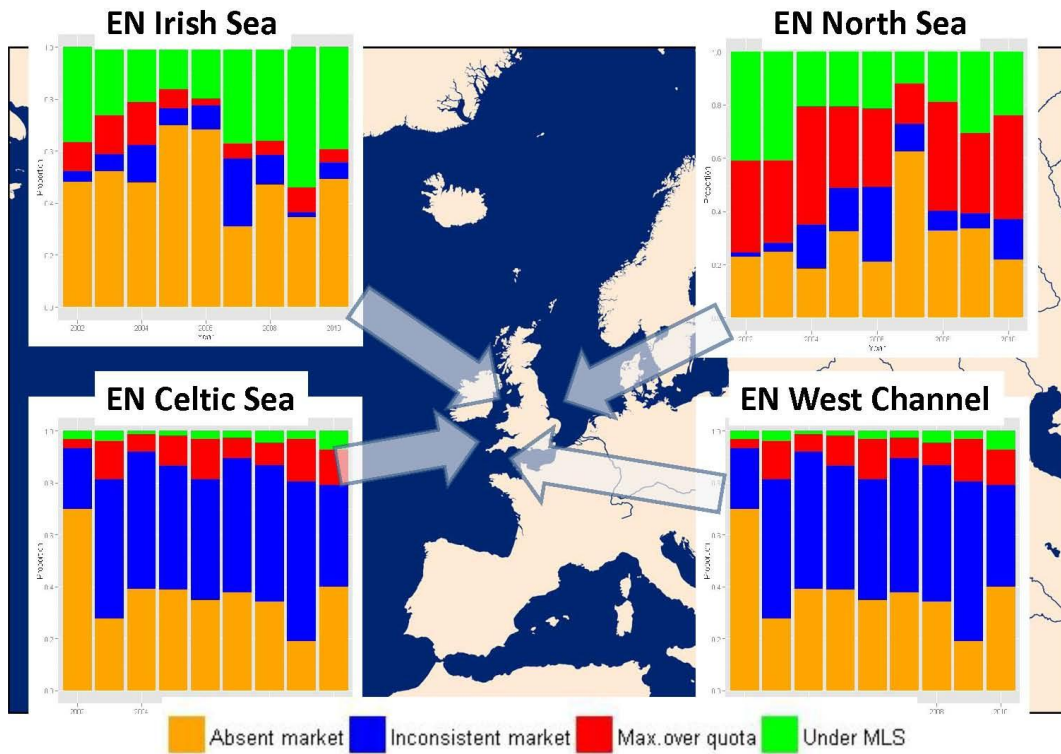
Figure 3.4 The relative contribution from each of the four inferred drivers for English fishing vessel operating in four different fishing g rounds.
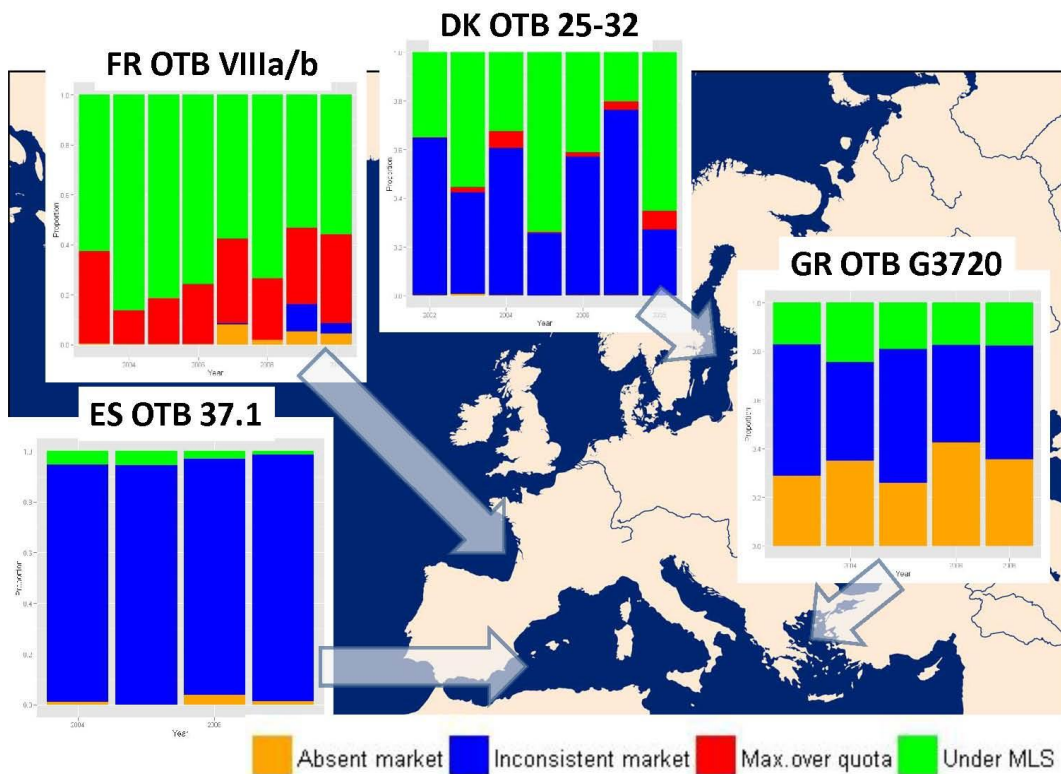

Figure 3.5. The relative contribution from each of the four inferred drivers for case study fisheries from France, Denmark, Spain and Greece

The results from the English programme demonstrated that all of the inferred drivers contributed substantially to the total discard quantity; therefore, there is not one principal cause for discarding at the national level. Examination of the English data identified clear differences in the relative importance of the four drivers at the scale of fishing ground. In the fisheries investigated, the spatial effect was more important in identifying the relative importance of discard drivers than the gear type or vessel length. The four European case studies, also demonstrated a different combination of primary drivers for the observed discard patterns. WP1, found that discard rates were more homogeneous across gear types than regions. These results would support the notion that setting discard management strategies at a regional level would be appropriate.

Reliability of results (specific to WP3)

The interpretation of results from the models used was limited by several technical reservations linked to the data and methods used. First of all, onboard observer data are known to suffer from bias, the extent to which is often unknown and likely different between different observer programmes. Similarly, the level of coverage of the programmes is typically low, ~1% of the total fishing effort, therefore all results assume that sampled trips are representative of the population of trips. Another weakness is that the data were not specifically collected for the purpose of analysing the efficacy of technical measures and environmental effects. Rather, the onboard observer programme is designed to estimate catch and discards of the main species caught by the principal fleets. Therefore, the analysis design is not balanced across the main factors likely to affect the amounts caught and/or discarded – event not across the variables; and the variables are often selected on the basis of what information is available. Some of this is accounted for in the modelling, but there might be other influential variables, for example, ecological factors, that are not fully accounted for in these results. Lastly, when price was included as a variable in the models this was based on weekly average prices which may not have identified shorter term price fluctuations, also price differences across ports may have resulted in a vessel travelling to another port to obtain a higher price rather than discard part of the catch. Knowledge about a vessels port of origin and port of landing would help to better understand the effect of price on discarding.

Main preliminary conclusions (WP3) including

From the outputs in this WP it was evident that discards are effected by a multitude of factors that differ by species and length group. Discard practices differ significantly in space and time and have been shown here to be influenced by gear type, mesh size, quota restrictions, MLS, year class strength, fish condition, catch composition and quota restrictions. Understanding the influences on discards and the relative importance of each influence is a requirement to developing successful mitigation measures.

There is good evidence from the case studies examined, that technical measures pertaining to more selective fishing gear have reduced discards. For example, the recently introduced gears in the Baltic (Bacoma 110 mm codend in the western Baltic, the New Bacoma 120 mm, and T90 120 mm) and in the French Nephrops fishery (flexible grid, square-mesh panel and increase in codend mesh size). However, the success of such measures is not guaranteed. The successful implementation of selective gear depends on developing an incentive framework that overcomes any short-term economic losses associated with their use and the fishermen's acceptance. In the example of the Danish Kattegat case study, economic incentives were the

driving force behind non-compliance with historic gear regulations but more recently introduced regulations were taken up by the industry and a reduction in discards could be demonstrated.

The outputs also demonstrate that spatial and temporal factors have a strong effect on discard patterns. Therefore, when considering new management measures to reduce discards, the spatial and temporal distribution of discards need to be taken account of, as these patterns could be used in the development of useful tools in reducing discards. Related to this was the finding that the drivers of discards were generally consistent across gears and vessel types within the same region but varied between regions, supporting to the notion that discard mitigation strategies should be developed at a regional scale.

Not all technical measures work to reduce discards and the removal of some technical measures needs be considered as part of an overall strategy to reduce discards. Removing the MLS for plaice in the North Sea Danish trawl fishery, for example, would substantially reduce discards and this could be coupled with a move toward catch limits (as opposed to landing quotas – see below). The catch composition regulations and quota restrictions in the French trawl fishery in the North Sea and East Channel were also identified as being an important driver of discards of cod. Furthermore, it was shown that up to 60% of the discards generated by English fishing vessels in the North Sea could be attributed to legislative drivers including quotas restrictions, catch composition regulations and MLSs. On the other hand, low compliance to MLS regulations in the Greek Case Study resulted in lower discarding.

Therefore, WP3 has demonstrated that the current objective to eliminate discards in European fisheries is in contradiction with several components of the current Common Fisheries Policy. The objective of MLSs and landing quotas are to disincentivise the catching of juvenile fish and to restrict fishing mortality. These measures do not meet these objectives in those fisheries that catch more than one species, which includes most European fisheries. So there is little incentive to avoid catching fish that are under the MLS, only to avoid landing them. Similarly, once the landing quota is fully utilised for one or more species, fishermen legitimately continue catching and discarding those species while targeting other species for which quota is available and unregulated species.

The alternative approach, as proposed by EU Commission, is to convert the current landings quotas to catch limits. The principle is to limit total catch for a single or group of species and when any one of the catch limits in a fishery are met, fishing activities stop. To maximise the revenue from their allocated catch limit, fishers are incentivised to avoid catching fish that would otherwise result in a curtailing of the fishing season and to avoid catching undersized, juvenile and low value fish, which would be deducted from their quota for little or no profit. This can be done through the use of more selective fishing gear, which has shown to be effective in the case studies examined here, or other changes in fishing practice. This would potentially eliminate all discards generated through legislative drivers.

Market forces were also shown to be an important factor in generating discards. In ICES VIIe, 86% of the discards generated by the English fleet were attributed to either and absent or inconsistent market. Within WP3 a schema was developed to illustrate how an alternative approach could be applied at different spatial scales (fishery, gear, region) and would address both market and legislative driven discards (Figure 3.6). The framework is founded upon two criteria, the fixing of fishing mortalities for commercial species through catch limits and a profitable activity for the industry. The framework is based on the CFP reform proposed by the EU Commission and the inferred drivers identified in this work.

For those catches for which there has been an absence of a market, so long as these are not protected species, in the schema we treat them as those derived from inconsistent markets. For this category, market development should be attempted for those species which are identified as being resilient to an increase in fishing mortality. If species are protected by legislation or are considered to have low resilience to an increase in fishing effort, then we ask whether there is any incentive to develop more selective fishing practices. In the absence of an incentive, the framework defaults to the introduction of catch limits. Catch limits come with the potential to uplift the landings quota, consequently, an economic inventive can be created to encourage fishermen to transfer to catch limits.

In circumstances where it is unsuitable to introduce catch limits, the introduction of conditional access is imposed. This approach is currently used widely in European fisheries, either in the guise of providing spatial access to fishing grounds, or allocating additional fishing effort to those fishermen using more selective fishing methods. The same process can be followed for the other two drivers of MLS and quota once an initial question has been posed in each case (Fig 3.6). If there remains a requirement to avoid catching juvenile fish and no additional quota can be sought then we look to developing incentives. Otherwise these fish can be landed and sold. Transferability of quotas can minimise quota-derived discarding and be achieved through purchasing and leasing quota, (mandatory) quota swaps and banking or borrowing quota from adjacent years. A high level of transferability of quota is a vital component in ensuring profitability of fleets both with the current EU quota system and the proposed catch limits.
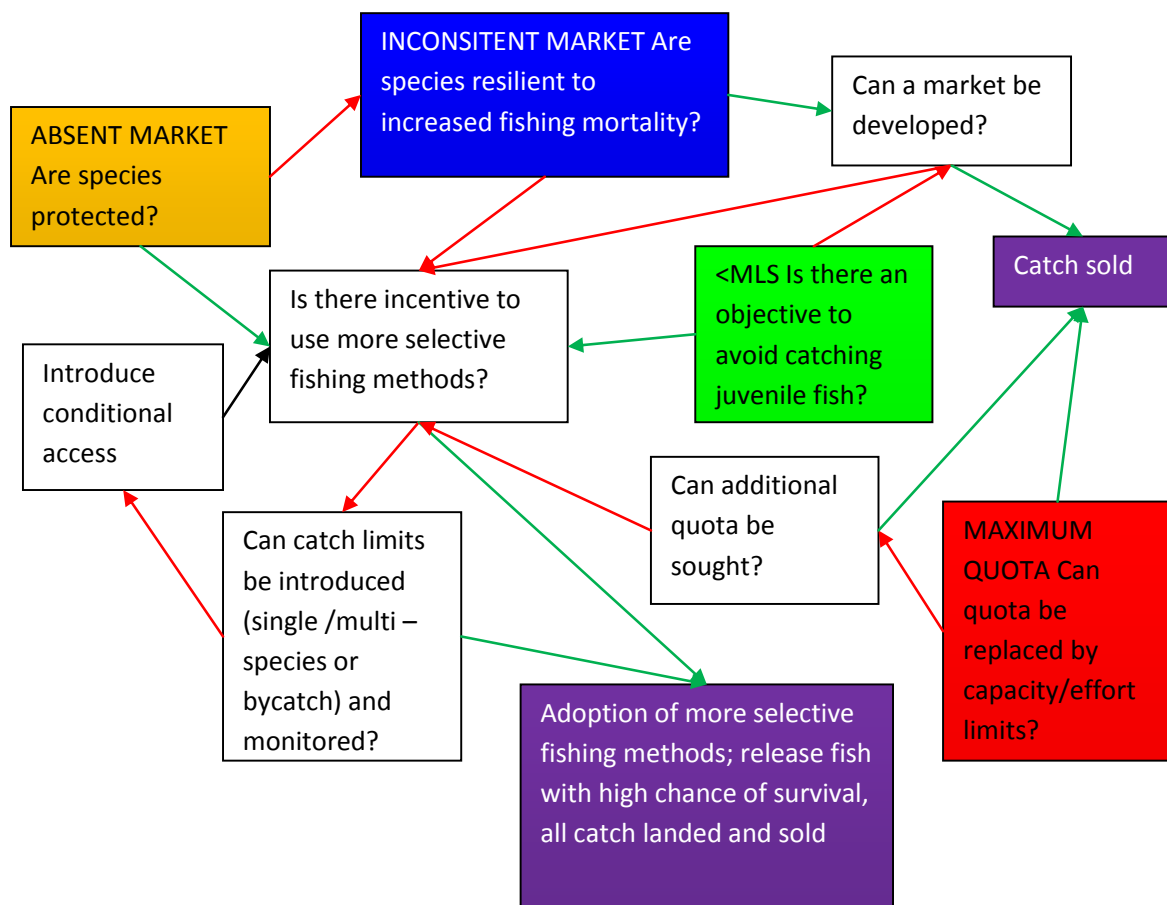
Figure 3.6. Schema illustrating a decision framework to minimize discards at spatial different scales. The framework is based on a on the four inferred drivers of discarding identified in this study, yes = green, no = red.

The framework can be applied at different scales and to different fisheries. The expectation would be that the process is followed by all relevant stakeholders, buyers, managers and fishermen etc, in a collaborative process. The aim of the process would be to eliminate discard mortality.

▪ **The expected benefits and usability of results**

Indicators of the key drivers of discards; a detailed analysis of the influences and effectiveness of technical measures in the case study fisheries. A tool to assist in the process of applying the most appropriate discard mitigation measures in a given fishery or region.

▪ **Possible implication for stakeholders and policy**

Identification of successful mitigation measures and many factors influencing and driving discarding; development of a framework, to be used by managers and other stakeholders to identify appropriate discard mitigation measures and strategies.

- **Possible recommendations for future work**

Establish confidence intervals in discard estimates in relation to adjustment to catch limits; forecast population dynamics outcomes and economic consequences of different scenarios of catch limits.

Survival estimates would help examine whether bringing catches ashore would increase mortality of caught fish.

Corrective actions suggested

Remove regulations that require fishers to discard, primarily current TACs, catch composition regulations, and replace with an incentive framework that enables fisheries to maximise their revenue within a system that restricts fishing mortality.

Papers, other publications and dissemination activities done.

Damalas, D. & V. Vassilopoulou, 2012. Slack regulation compliance in the Mediterranean fisheries: a paradigm from the Greek Aegean Sea demersal trawl fishery, modelling discard ogives. Fisheries Management and Ecology; doi: 10.1111/j.1365-2400.2012.00860.x

Feekings et al (2012). Feekings J, Bartolino V, Madsen N, Catchpole T (2012) Fishery Discards: Factors Affecting Their Variability within a Demersal Trawl Fishery. PLoS ONE 7(4): e36409.

Madsen et al (in press) Discarding of plaice (*Pleuronectes platessa*) in the Danish North Sea trawl fishery, Niels Madsen, Jordan Feekings, Peter Lewy. In Press: Journal of Sea Research, Available online 15 May 2012

Nikolic, N., Diméet, J., Fifas, S., Salaün, M., Ravard, D., Fauconnet, L., and Rochet, M.J. In preparation. Selective devices contributed to reduce discards in the *Nephrops* trawl fishery in the Bay of Biscay.

- **Results for WP3**

ICES ASC: Session C:

Presentation: Using inferred drivers of discarding to identify fishery specific mitigation measures (ICES ASC 2012 C:11) T Catchpole

Presentation: The impact of gear regulation changes on discard rates: the case of the Baltic Sea cod fishery (ICES CM 2012/C:02) Jordan Feekings, Niels Madsen, and Peter Lewy

Presentation at Discards Action Group (UK) - meeting of a wide range of stakeholders http://www.seafish.org/retailers/responsible-sourcing/protecting-fish-stocks/discards/discard-action-group

Annual marine fisheries monitoring meeting with Department for Environment, Fisheries and Rural Affairs (Defra – UK environment ministry) - 'MF1002 (2008-13) Practical steps to reduce discarding & MF1211 (2009-12) Badminton (Marifish)'

Cefas science audit to international group of marine scientists 'Fisheries, Monitoring and Assessment, Discards: Monitoring & Mitigation, Tom Catchpole'

Presentation to Cefas observers at bi-annual meeting 'Fisheries, Monitoring and Assessment, Discards: Monitoring & Mitigation, Tom Catchpole'

Discard of plaice (*Pleuronectes platessa*) in the Danish North Sea trawl fishery. / Madsen, Niels; Feekings, Jordan P. 2011. Poster session presented at International Flatfish Symposium, Ijmuiden, The Netherlands.

WP 4 Socio-economic and institutional incentives for discarding

Objectives and tasks

The objective of WP 4 is to develop an understanding of socio-economic and institutional drivers and incentives on fishers' behaviour with regard to selectivity and discard practices.

Methods used and results

▪ **Literature review leading to a theoretical and operational framework**

The first step was a theoretical discussion of individual behaviour as embedded in an institutional framework of state, market and the human community. Within this framework factors which could influence behaviour in regard to discards and eventual selective behaviour were identified from articles and reports on discards, as well as Badminton WP3. The factors mentioned were related to the institutional framework which structured the construction of a list of factors which potentially influence the discards and selective behaviours (Table 2 below). This work is documented in the working paper D1 from WP 4, attached to this report.

Table 2: Specified list of factors which potentially influence the discards and selective behaviours.

Main area	General factors	Specific factors
Natural conditions	Stock related conditions	Mixed/single species fishery Natural changes in stock availability
	Condition for the fishing process	Sea bed and other physical conditions Weather conditions
	Structural conditions – fleet structure	Fixed investments in vessels (and partly equipment)
Community	Dominant norms regarding discards	General view of discard Institutional knowledge regarding volumes, consequences etc. of the discard Social norm enforcement
	Identity	The fishers' perceived role in relation to the management system
	Learning	The fishers´ interpretation of the management system and dialogues with the management regarding the discards Individual and collective initiatives to learn
State	Regulations and measurements	Input/output regulation Technical measures, including closures
	Decision rules and procedures	Legitimacy of the fisheries regulation
	Communication structures	Formal and informal forums Communication "climate" - dialogue/position marking
	Control and enforcement	Interpretation of strength of control and enforcement Level of registered non-compliance
Market	Economic incentives	Market prices Interpretation of market pressure for certain "qualities"
	Tactical investments in technology	Fishing gear/equipment for tracing, handling and storing

- **Case studies**

The list of factors influencing discard behaviour was used as a check list for the case studies of fishers´ interpretation and behaviour in regard to discard in three trawl fisheries cases in Denmark, Greece and England. In the same process the relevance of the specific factors of the list were tested.

One of the case studies was based purely on an analysis of reports from three interview-based analysis of discard behaviour and interpretations among fishers in three English fisheries (trawl fishers in NE, NW and SW), conducted on behalf of CEFAS in 2009-2010.

Two other case studies (Denmark: trawl in Kattegat and Greece: trawl in Ionian and Aegean Seas) was based on desk study and semi-structured interviews. Desk studies provided data on structural conditions and to some extent also behaviour. Other behavioural elements as well as

the fishers' interpretation of discard and the various factors were gathered through semi-structured personal interviews conducted in selected ports in Denmark and Greece. During the interview visits, observations of behaviour and attributes were also noticed as input for the interpretation of the interviews. The methodology for the interviews is described in working paper D1.

The case study work resulted in three case descriptions of different levels of detail (due to difference in method in data gathering). The case studies can be used as basic information for projects on discard in each area. The Danish case study description is expected to be used as background for work in relation to at least two later projects (FP7 project Socio-EC and interreg project ØBJ-FISK).

- **Analysis of results of case studies**

Based on the analysis of influential factors in each of the case studies the results were compared across the three cases: general findings; dominant factors, patterns of influential factors, remarkable differences.

Further the list of factors was evaluated based on the use in the three case studies.

Discussion of results and their reliability

The results from the work are:

1)   Development of a list of factors potentially influencing discard (see Appendix D4.1).

   a. The list of potential factors has been developed based on literature review and therefore based on empirical data. The usefulness has been tested by use in the three case studies. It was useful here, but need to be used and adjusted in other cases to be fully reliable as a general tool. It has only been tested within EU settings.

2)   Three individual case studies of fishers' perception of discards in three selected cases of bottom trawl fisheries in England (three fisheries), Denmark and Greece(see Appendix D4.2).

   a. The Danish and Greek case studies are based on desk study of back ground for the fishery and discard as well as the institutional settings. The central part regarding fishers' perceptions is based on personal interviews. The use of qualitative interviews provides a deep insight in the perceptions of the interviewed fishers, which is validated or developed in following interviews. The findings thus are reliable for the type of interpretations, though not necessarily representative for the whole group of fishers.

   b. The English case study is based on analysing reports from previous interviews. The reports were made in a slightly different context. There is therefore a risk of a bias in perceptions analysed from the reports.

3) Analysis across the cases to see general patterns in factors influencing discard behaviour (see Appendix D4.3).

   a. The analysis is based on three cases with differing strengths. Other general findings and patterns could be found from a broader range of cases. But the generated conclusions are well founded in the three case studies.

Main conclusions

- **Conclusion on the cross case analysis**

- There is a lack of common definition and understanding of discards among the fishers – and between fishers and other stakeholders. To be able to use dialogue and fisher involvement a common understanding of the problem is needed – or at least the differences need to be clarified

- Fishers tend to take own initiatives to develop new mitigation tools and gear with higher selectivity. Conditions for this seem to be a tradition of such collective acts combined with political emphasis on the issues and direct regulative pressure.

- The effect of one factor (measure) often depends on the interrelation to other factors. A specific measure in isolation might create a certain incentive. But other factors can strengthen the incentive or counteract it. In pre-assessments or evaluations the whole range of factors should be included.

- **Conclusion regarding the list of factors potentially influencing discard behaviour**

The list highlights factors that in isolation, but especially in combination, influence discard level and behaviour. It can be used for assessing factors underlying discards. Additional case studies could lead to supplementing specific factors, and reformulation of others (clarifying the discard problem definitions among the stakeholders, the price factor should include interpretation of the market and potential net income). A few of the specific factors of the list studies (social norm enforcement, handling and storing capacity) might turn out to be less important. More case studies are needed to generalize this result.

- **The expected benefits and usability of results**

The list of factors should function as guidance for case studies in preparation of recommendation of specific mitigating measures when using the simulation models proposed in the Badminton project. The list could be used in other relations where influential factors in the fishers perceptions should be identified and openings for implementation of mitigating measures identified.

The specific case studies could be used in relation to eventual need of proposing and implementing mitigating measures in the surveyed fisheries. As they partly describe the broader context of the fisheries they could be partly used for other fisheries in the near surroundings.

- The Danish case study will further be used for further research and implementation in the FP7 research project Socio-EC and the INTERREG project at a more implementing level; Economic sustainability in the Nephrops Fisheries in the Kattegat-Skagerrak region.

The general findings have shown the interrelation between several factors and has been used in the simulation model to emphasize the importance of seeing proposed measures in the social and economic context as well as context of other measures.

- **Possible implications for stakeholders and policy**

The list and the case studies illustrate that especially policy should take the context of factors influencing discard (measures as well as other factors) into consideration when the effect of a

new measure is assessed. The list offers as tool for taking the known possible factors into consideration.

- **Possible recommendations for future work (further research, dissemination, application)**

The list of factors provided a good framework for the case studies. Never the less the list should be applied in other cases in order to get a broader base for assessing if some factors are less important for discard behaviour and therefore should be excluded from the list. Likewise some of the specific factors should be reformulated based on experiences from the case studies.

List of papers, other publications and dissemination activities done.

Paper

A paper will be submitted to the ICES Journal of Marine Science, special issue on bycatch and discard: Eliasen S., Papadopoulou N., Vassilopoulou V., Catchpole T.: Socio-economic and institutional incentives influencing fishers' behaviour in relation to fishing practices and discard.

Reports:

- Eliasen and Christensen, 2012: The institutional basis for discard behaviour. The theoretical basis for case studies in the Badminton project, WP 4.

- Eliasen, Papadopoulou, Vassilopoulou, Berner L. October 2012: The Badminton project WP 4 report: Case studies of trawl fisheries in Denmark, Greece and England and evaluation of incentive framework.

- Eliasen S., Papadopoulou N., Vassilopoulou V., Catchpole T.: Socio-economic and institutional incentives influencing fishers' behaviour in relation to fishing practices and discard. Presentations:

- Presentation of the Badminton project and the Danish WP 4 plans at meeting with Danish Fishermen's' Association: 17/8-2011

- Eliasen S: Socio-economic and institutional incentives influencing fishers' behaviour in relation to fishing practices and discard. ICES Annual Science Conference 2012 in Bergen. 20/9-2012 Theme session C: Bycatch and discards: from improved knowledge to mitigating measures

- Vassilopoulou, V., A. Dogrammatzi, K. N. Papadopoulou, A. Palialexis, J. Haralabous and S. Q. Eliasen.: Trawl fishers' perceptions as complementary inputs in the context of allying an ecosystem approach to the management of the Mediterranean multi-species fisheries. Poster presentation. ICES Annual Science Conference 2012 in Bergen. 20/9-2012 Theme session I: Multidisciplinary perspectives in the use (and misuse) of science and scientific advice in Marine Spatial Planning.

WP 5 Mitigation measures to reduce discards in European waters

Objectives and tasks

Deliverables specified for this work package were:

D1. A report with technical measures for discard minimization and proposed improvements.

D2. Manuscript of a peer-reviewed article on simulation results regarding optimal size and shape of mesh and technical measures.

D3. Manuscript of a peer-reviewed article on the strengths and weaknesses of different fisheries managements systems with regard to discard.

Methods and results obtained so far

An article, How can discards in fisheries be mitigated? SWOT analysis of discard mitigation measures, to be submitted to ICES Journal of Marine Science will fulfil both deliverables D1 and D3. (see Appendix D5.1) Mitigation measures evaluated in the article were identified after a thorough discussion and literature review on different fisheries management systems. They are:

1. Temporary/Spatial restrictions.
2. Selective practices.
3. Improving existing and/or finding new markets.
4. Change of MLS.
5. Change of catch composition.
6. Multi-species quota.
7. Catch quota, not landing quota.
8. Discard ban.
9. Fishing effort and capacity.
10. Transferability of quota.
11. Co-management.
12. Society awareness of discard issues.

Each mitigation measure is evaluated using Strengths – Weaknesses – Opportunities and Trends (SWOT) analysis performed by scientists who all have expertise in fisheries science. SWOT analysis is an analytical tool used in business management. In SWOT analysis the analyst lists factors regarding the business into four categories; internal positive and negative factors (strengths and weaknesses) and external positive and negative factors (opportunities and threats). These lists can be used to build a business strategy and identify ways of using strengths and opportunities to outweigh weaknesses and threats. The discard mitigation measures SWOT analyses were carried out in a workshop, held in Reykjavik, Iceland during 29-31st May 2012. The participants – the Badminton partners –together cover a comprehensive view of discards, across both EU regions and issues (technology, onboard observer programmes, discard quantification and analysis, management).

D2 was finished with a publication in Journal of Northwest Atlantic Fisheries Science. The article, Understanding the Size Selectivity of Redfish (*Sebastes* spp.) in North Atlantic Trawl Codends, with Bent Herrmann from DTU Aqua as first author (see Appendix D5.2), describes a study on the size selectivity properties of diamond mesh codends on redfish. The so-called FISHSELECT methodology was further expanded and applied to available published data for redfish with new sea trial data and FISHSELECT predictions into a single comprehensive quantitative framework. FISHSELECT is a fish morphology data- and simulation based

methodology that can be applied to investigate the basic size selective properties of meshes of different shape and size for individual fish species. The methodology has been successfully applied for cod (*Gadus morhua*) and haddock in the North Atlantic. However, cod and haddock belong to a different fish family (Gadidae) than the redfish (Sebastidae). This difference has potential implications for selectivity studies as the general body shape of the Sebastidae species in question differs substantially from that of the Gadidae species mentioned.

Discussion of the results and their reliability

Main results from the SWOT analysis and results from analysis on how mitigation measures could complemented by each other are discussed in the paper. Results give a thorough description on strengths and weaknesses of each mitigation measure as well as guidance for their implementation.

As an example of results preliminary results for Temporary/Spatial restrictions are shown:

Temporary and/or spatial restrictions are widely used and have shown to be effective for many fisheries. They can be used to encourage fishermen's use of other mitigation measures, for example gears with improved selectivity. Other mitigation measures, such as change of MLS and catch composition, can have a knock on effect on temporary and/or spatial restrictions. Downsides of this mitigation measure are the shift of fishing effort to other areas, but this could be controlled to some extent by managing fishing effort and capacity. The transferability of quotas will limit the mismatch of vessel's existing quota when displaced from an area with a closure. Lastly, temporary/spatial restrictions could be complemented with co-management as the restrictions could be more effective, and complied with, if they are based on fishers' experience.

Because the workshop was organized by the end of the Badminton project, the knowledge accumulated during the works and common expertise built along the project were very useful in bringing the appropriate understanding to discussion.

Main conclusions

- **The expected benefits and usability of results**

The article is proposed as a tool for fisheries managers to choose methods to mitigate discards. Choosing and combining mitigation measures can be done based on the review of their strengths and weaknesses, and the analysis of their combined effect.

- **Possible implication for stakeholders and policy**

The method and data presented in the redfish size selectivity study could also form the base for investigating the size selection of redfish species in other fishing gear devices than diamond mesh codends. For example a design guide describing size selection of *S. marinus* in square mesh codends could be constructed based on the data described in this paper by using the method described in a case study for haddock in Krag et al. (2011).

The ability to reproduce the complex characteristics of the cross-section shapes of *S. marinus* using the mathematical description for the drop-shape family of models, which requires only two independent parameters to be estimated as function of fish length, highlights the power of

this type of parametric description to model the cross-section shapes of fish. This type of mathematical description could in the future be applied to other fish species. Further, it could also be applied as a tool to categorize fish species morphologically according to their mathematical description. The selection of different models to describe the transversal contour of *S. marinus* at different positions along its length also represents a new way of quantifying how its shape changes along its length.

Dissemination activities

Herrmann, Bent; Sistiaga, Manu; Nielsen, Kåre N.; Larsen; Roger B., 2012. Understanding the size selectivity of redfish (Sebastes spp.) in North Atlantic trawl codends. Journal of Northwest Atlantic Fishery Science (ISSN: 1813-1859) (DOI: http://dx.doi.org/10.2960/J.v44.m680), vol: 44, pages: 1-13

Sigurðardóttir, S., Kemp Stefánsdóttir, E., Condie, H., Margeirsson, S., Catchpole, T.M., Bellido, J. M, Eliasen, S., Goñi, R., Madsen, N., Palialexis, A., Uhlmann, S., Vassilopoulou, V. and Rochet, M.J. In preparation. How can discards in fisheries be mitigated? An evaluation of discard mitigation measures. To be submitted to ICES Journal of Marine Science.

WP 6 Project management and co-ordination

Objectives and tasks

The objectives of this work package were to coordinate and manage the project so that foreseen activities would be completed as agreed.

Methods used and Results obtained

The following tasks were carried out in WP6:

Task 6.1: Management of the project team and it's progress; organize and convene six (6) project meetings, and six (6) steering committee meetings which were held after project meetings; production of minutes from these meetings, with action lists and division of work loads. Collation of inputs for the Reports was conducted.

Task 6.2: Internal communication and the required tools.

Task 6.3: Drafting a Consortium Agreement between Participants and distributing the copies.

Task 6.4: Organization of internal Work Package Meetings when appropriate, either back-to back with project meetings, or via skype.

Task 6.5: Preparation of the Mid-term and the Final Report, and submission to the MariFish Call Secretariat.

Task 6.6: Facilitate the communication between the MariFish Committee and the project partners

Task 6.7: Coordination of cooperation between related and relevant, possibly EU funded, projects

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Project and Steering Committee Meetings

The project meetings were held in the following places:

Badminton kick-off meeting: Paris (France) 12-13 November 2009

Badminton 1st meeting: IJmuiden (the Netherlands) 16-18 May 2010

Badminton 2nd meeting: Murcia (Spain) 16-18 November 2010

Badminton 3rd meeting: Rhodes (Greece) 16-18 May 2011

Badminton 4th meeting: Charlottenlund (Denmark) 16-18 November 2011

Badminton Final meeting: Reykjavik (Iceland) 29-31 May 2012

Minutes produced at each meeting are provided (see Appendix D6.1a-f). During the last day of each meeting, Steering Committee Members convened to evaluate progress and plan further activities.

Deliverables of this WP related to setting the Project Website, completing the Consortium agreement and drafting and submitting the Mid-term Report were fulfilled and were included in the Mid-term Report Annex, while the compilation of the Final Report is the Final Deliverable of WP6.

Dissemination of the project results

Special Theme session

A Theme session dedicated to bycatch and discards was organized by the Badminton partners at the Annual Science Conference of the International Council for the Exploration of the Seas, Bergen, Norway, 17-21 September 2012. Session title was: "Bycatch and discards: from improved knowledge to mitigation programmes", Conveners: Tom Catchpole (UK), Steve Cadrin (USA), and Marie-Joëlle Rochet (France).

Session synopsis: Discarding continues to be an important problem in world fisheries. Discarding is a way for fishers to adjust their landings to the legal and market constraints, but is largely considered as a waste of natural resources and a contribution to the depletion of stocks that are under high fishing pressure. In the EU and other regions, data collection onboard commercial vessels has intensified (e.g., the new Data Collection Framework launched in 2008, Standardized Bycatch Reporting Methodology in the Northeast US, and increased at-sea observer coverage in other regions). Member states, the Sub-Group on Research Needs of the Scientific, Technical and Economic Committee for Fisheries, several ICES expert groups and various research projects undertook analysing these data. Many jurisdictions, including the European Commission, are preparing regulations to reduce or ban discards. To design effective regulations, an understanding of the extent and processes of the issue is required, including a thorough understanding of the technical, legal and socio-economic incentives to discard. In 2012 it is time to put together the results of this research and to build on the accumulated knowledge to elaborate mitigation measures and programmes.

Across worldwide fisheries, papers were invited on the following topics:

- sampling strategies and estimation methods

- quantification of spatial and temporal distribution and magnitude of discards as well as discard mortality

- indicators of discard issues: amounts and characteristics of discards, selectivity of fishing at various scales

- analyses of the factors that determine discard amounts (such as environmental settings, year-class strength, community composition, fishing practices…)

- analyses of the efficiency of technical regulations in force, and retrospective analyses of the efficiency of such measures in the past

- analyses of socio-economic and institutional drivers and incentives that influence fishers' behaviour in regard to selectivity and discarding

- proposals of potential mitigation measures, from technical measures to integrated, inter-disciplinary approaches and cooperative behaviour.

The response to this theme-session was very good and a number of contributions were proposed on each of these themes. Nineteen oral presentations and ten posters could be accommodated, among which six Badminton oral presentations and five Badminton posters (see Appendix D6.2). Attendance and participation in the session were encouraging, illustrating increasing interest in the topic. The understanding of both human and ecological drivers of discards has greatly improved, as well as the appraisal of the magnitude of the issue by fisheries and areas. This expanded knowledge base provides appropriate basis for discussing the discards management measures proposed in various settings, especially the discard ban discussed under the reform of the European Union Common Fisheries Policy. From the presentations and discussions a consensus seemed to emerge that bottom-up solutions are the way forward to manage discards.

The report of the Theme session is appended (see Appendix D6.3) and is also available online (http://www.ices.dk/iceswork/asc/2012/themesessions/TS%20C%20report%20final.pdf).

Joint publication of project results

An agreement is made with the ICES Journal of Marine Science editors that a special set of papers dedicated to bycatch and discards is going to be published together as an output of both the Badminton project and the ICES ASC Theme Session. Deadline for submission is 31 December 2012. Manuscripts will be peer-reviewed according to the normal procedure in this journal.

Hence, deliverables in the form of peer-reviewed MSs to be submitted to ICES Journal of Marine Science are not finalised yet and only a draft version is provided in the Appendix. The latter referring to the delay of producing certain deliverables, along with amendments made in specific planned activities and deliverables, driven by appropriate adaptations to project requirements, are mentioned in the section "Adaptations to the BADMINTON work-plan according to a set of requirements applying on the workflow (see Appendix D6.4).

4. LIST OF APPENDICES

WP	Appendix	Title
WP1	D1.1	Uhlmann S., Van Helmond A.T.M., Kemp Stefánsdóttir E., Sigurdardóttir S., Haralabous J., Bellido J.M., Carbonell A., Catchpole T., Damalas D., Fauconnet L., Feekings J., Garcia T., Madsen N., Mallold S., Margeirsson S., Palialexis A., Readdy L., Valeiras J., Vassilopoulou V., Rochet M-J., 2012. Discarded fish in European waters: general patterns and Contrasts (submitted to *ICES J. Marine Science*).
	D1.2	Poos J.J., Aarts G., Vandemaele S., Willems W., Bolle L.J., Van Helmond A.T.M., 2012. Estimating spatial and temporal variability of juvenile North Sea plaice from opportunistic data (*Journal of Sea Research*)
WP2	D2.1	Rochet M-J., Bellido J.M., Catchpole T., Condie H., Burny C., Fauconnet L., Madsen N., Mendoza M., Palialexis A., Vassilopoulou V. 2012. What do European Fleets Discard? Prototype of an indicator dashboard based on onboard observer data. (Working document)
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WP4	D4.1	Eliasen S. and Christensen A-S. 2012. Institutional basis for discard behaviour. The theoretical basis for case studies in the Badminton project. (Working document)
	D4.2	Eliasen S., Papadopoulou K, Vassilopoulou V., Berner L. 2012. The Badminton project WP 4 report: Case studies of trawl fisheries in Denmark, Greece and England and evaluation of incentive framework. (Working document)
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WP5	D5.1	Sigurðardóttir S., Kemp Stefánsdóttir E., Condie H., Margeirsson S., Catchpole T., Bellido J. M, Eliasen S., Goñi R., Madsen N., Palialexis A., Rochet M- J., Uhlmann S. S., Vassilopoulou V. 2012. How can discards in fisheries be mitigated? SWOT analysis of discard mitigation measures (to be submitted to *ICES J. Marine Science*)
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WP6	D6.1a	Minutes of kick-off meeting in Paris
	D6.1b	Minutes of 1st meeting in the Netherlands
	D6.1c	Minutes of 2nd meeting in Spain
	D6.1d	Minutes of 3rd meeting in Greece
	D6.1e	Minutes of 4th meeting in Denmark
	D6.1f	Minutes of final meeting in Iceland
	D6.2	Timetable of the ICES ASC 2012 Theme Session C
	D6.3	Report of the ICES ASC 2012 Theme Session C
	D6.4	Adaptations to the project work-plan