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DiscardLess

Strategies for the gradual elimination of discards in European fisheries

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Deliverable 2.1

Report on the available economic data related to discard, on bio-economic fishery models, on the current knowledge on discard incentives, perception, attitudes and resulting fisher behaviour and on knowledge gaps for all case studies fisheries.

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Executive Summary

The task is to ensure that the project builds on the best available information. Task 2.1 will review the most recent knowledge base of the economic and social aspects of discarding and will identify the most important gaps across all case studies.

The scope is to develop and apply an evaluation system that takes into account that economics (profit) is the main driver for the fishermen and how this impacts the behavior of the fishermen. The applied methodology analyses fishermen's behavior, models and data that could be used to assess the economic consequences of the landings obligation. It is important to emphasize that the methodology must be based on solid economic theory. Discards of fish have been subject to concern in international fisheries conventions since the 50'es and 60'es. Empirical research about mitigating catches of unwanted species took place from the beginning of the 90'es with numerical economic analyses about effects of fishing gear changes (mesh sizes and panels). A conference about discard was organized by FAO in Japan in 1996. Theoretical work in a socio-economic context developed from the mid 90'es and it is useful to distinguish between two approaches 1) unwanted catches i. e. non-target species in open access and ITQ managed fisheries and 2) high grading, which is defined as discard of low value fish in order to maximize profit by making room for more valuable fish. As such, high grading will not take place until certain restrictions become binding.

The literature survey identified a number of reasons for discarding fish. To summarize, the incentive to discard depends on (in non-prioritized order): 1) Species composition in harvest 2) Price on fish 3) Processing costs on board the vessel 4) Catchability rates 5) Discard costs 6) Penalty for violation of rules 7) Probability of being detected 8) Management system 9) Impact on stock abundance 10) Distance to fishing grounds.

Models selected for assessing the repercussions of the landings obligations must comply with economic theory and be applicable with available data. The selected models are: Fishrent, LOEB, FLBEIA, MEFISTO and Fcube.

Case studies are reviewed. Among the nine cases of the project a number are selected for economic analyses. These cases are reviewed in terms of data availability and model applicability. Furthermore on-going national projects concerning the discard ban are identified. All selected models are designed to use cost and earnings data from the EU Data Collection Framework. This information is combined with information about fish stocks and magnitude of discard from ICES and national sources. The knowledge gaps are mainly associated with data concerning high-grading caused by physical limitations on board the vessel, which is considered to play a minor role for the current magnitude of discard compared to the other causes for discard.

Contents

1 The task of 2.1

Knowledge of the socioeconomic effects of the landing obligation is developing rapidly as the time of implementation approaches. To ensure that the project builds on the best available information, task 2.1 will review the most recent knowledge base of the economic and social aspects of discarding and will identify the most important gaps across all case studies. This includes analyses of the models and data available including cost data, and text information on the perceptions and attitudes towards discards. Existing knowledge about incentives and disincentives (management and market conditions) on fisher behaviour will be examined, including documents from e.g. RACs and national projects

A plan for addressing knowledge gaps such as imperfect knowledge of incentives and motivation to discard or and gaps in comparable cost data across countries and fisheries segments will be defined to the extent possible.

Outline

Scope

a. Important economic aspects
b. Methodology (based on solid economic theory)

Selection of models and data

a. Peer reviewed articles (often purely theoretical)
b. Grey literature (often descriptions and data)
c. Model descriptions and associated data (demand)

2 Scope

The scope is to develop and apply an evaluation system that takes into account that economics (profit) is the main driver for the fishermen and how this impacts the behavior of the fishermen.

The applied methodology analyses fishermen's behavior, models and data that could be used to assess the economic consequences of the discard ban. This implies that

1. The system (fishery) must be delineated, described and understood in a socio and business economic context
2. Fishermen's behavior must be understood and modelled
3. The role of by-catch, discard and illegal fishery must be identified and described
4. The system must be valuated with and without changes in pertinent management rules
5. Calculations are carried out by use of prices and costs
6. The result is assessed

This means that studies without economic contents will not be addressed apart from the cases where they contain data that is of interest to conduct economic calculations. It is important to emphasize that the methodology must be based on solid economic theory. The type of analyses will be *with and without*, which implies that analyses will apply a base case without landings obligation of fish (discard) and compare this base case with alternative scenarios with landings obligation (no discard).

Furthermore, the selection of literature will be delineated with respect to restrictions imposed on the fishery. It implies that literature about management measures will not be addressed as well as the compliance literature will not be included unless there is a clear relation to discard. However, these limits may be difficult to find exactly.

Restrictions are imposed by the Government because the objectives of society and fishermen differ. Fishermen tend to use more effort that socially optimal because of market failures. Such failures are the impact on other fishermen by his fishing activity, lack of price formation and information about the abundance of the fish stocks. But also congestion on the fishing grounds and the impact on other fishermen by the choice of gear are market failures. In an unregulated open access fishery this leads to race for fish and waste. Part of this race has been mitigated by the EU Common Fisheries Policy by use of TAC and quotas and limited access of fishing effort.

From society's point of view the general objective is to maximize the welfare (W) from the exploitation of a scarce resource i.e. :

$$\text{Max } W=f(h, y, z)$$

Subject to:

$$\dot{x} = F(x) - h$$

$$\dot{u} = G(u) - y$$

$$\dot{v} = K(v) - z$$

Where h is provisioning of material goods including fish to a market, y is the yield from natural resources (non-target species) that do not fetch market prices including by-catches of fish (discard), birds and animals, z is the intellectual well-being of humans knowing that nature is in a good condition (amenity, heritage etc.). h, y and z are not necessarily positively correlated which means that an increase in h could entail a decrease in both y and z. The first restriction specifies the change, $\dot{x}$, in the fish stock x, the second one specifies the change, $\dot{u}$, in the non-target species u, and the third one the change, $\dot{v}$, in the intellectual stocks v i.e. the pleasure of knowing that the marine environment is in a god condition.

This is in fact a complicated system as all the dynamics of the marine system ultimately have to be included to maximize welfare. A genuine socioeconomic approach is not pursued as this entails use of opportunity cost concepts, estimation of shadow prices for goods not fetching a price on a market and long term considerations. From society's point of view the objective is to maximize welfare and for fisheries the objective is to maximize the resource rent, which is the remuneration of the fish stocks after production factors labour and capital have been remunerated. Instead emphasis is placed on a business economics approach i. e. *h* and partly *y*. From a business point of view the objective is to maximize profit (Π) to the fishermen from the exploitation of a scarce resource. As the fishermen do not take remuneration of the fish stock into account, theoretically maximization of welfare, resource rent and profit will not to exactly the same result. The fishermen's objective is to maximize profit form harvest of fish i. e.

$$Max\ \Pi=f(h)$$

If this equation is transformed into the usual (linear) profit maximization equation for fisheries and $h=g*x*E$, where g is a catchability coefficient, x is fish stock, E is fishing effort and p is the price on fish, the function looks:

$$Max\ \Pi=p*g*x*E-c*E$$

Discarding fish is partly a result of the possible contradiction between society's maximization of *W* and fishermen's maximization of *Π*, and the aim is to reduce that contradiction by introducing incentives to the fishermen to exploit the resource in a way that maximizes *W*. From that point of view society will impose resource restrictions in terms of how much could be caught of each species by setting catch quotas according to the yield the stocks can produce. It implies that *h* and *y* are restricted by society. The rest of the paper focuses mainly on the behavior of the fishermen in their pursuit of profit maximization.

Figure 1 below may help to understand the methodology and to scope the topic. In a system with no restrictions fishermen will land fish and discard in order to maximize profit and try to apply effort according to that (box 11). The implementation of the differences between fishermen's and society's objectives are reflected by box 3. These restrictions, however, although aiming at, will not always secure maximization of welfare. Restrictions will influence the fishermen's use of effort (box 1) and hence the cost and the revenue derived from exploiting the fish stocks (box 2) in producing catches (box 4). This part of the system is considered unaltered in the analyses under WP2 as the scope is to access economic repercussions of the landings obligations.

Focus is placed on what happens in boxes 5-11. Catches are either marketable or not, or caught illegally as a consequence of the restrictions listed in box 3 and that fishing is usually not completely selective (by-catch in box 4). The illegally caught fish is put on the market if it has a value net of fines as a result of detection. Otherwise the fishermen will discard this fish when the aim is to maximize profit. Even if the fish is marketable (box 5) it is not certain it will be landed if it is profitable for the fishermen to discard the fish, see section 3 for a more extensive analysis. On the other hand even if the fish could be marketed and fetch a good price restrictions imposed by the government (box 7) may force fishermen to discard some of the catch. This leaves landings distributed on the boxes 8-10. These boxes are the key objects for the analyses of WP2.

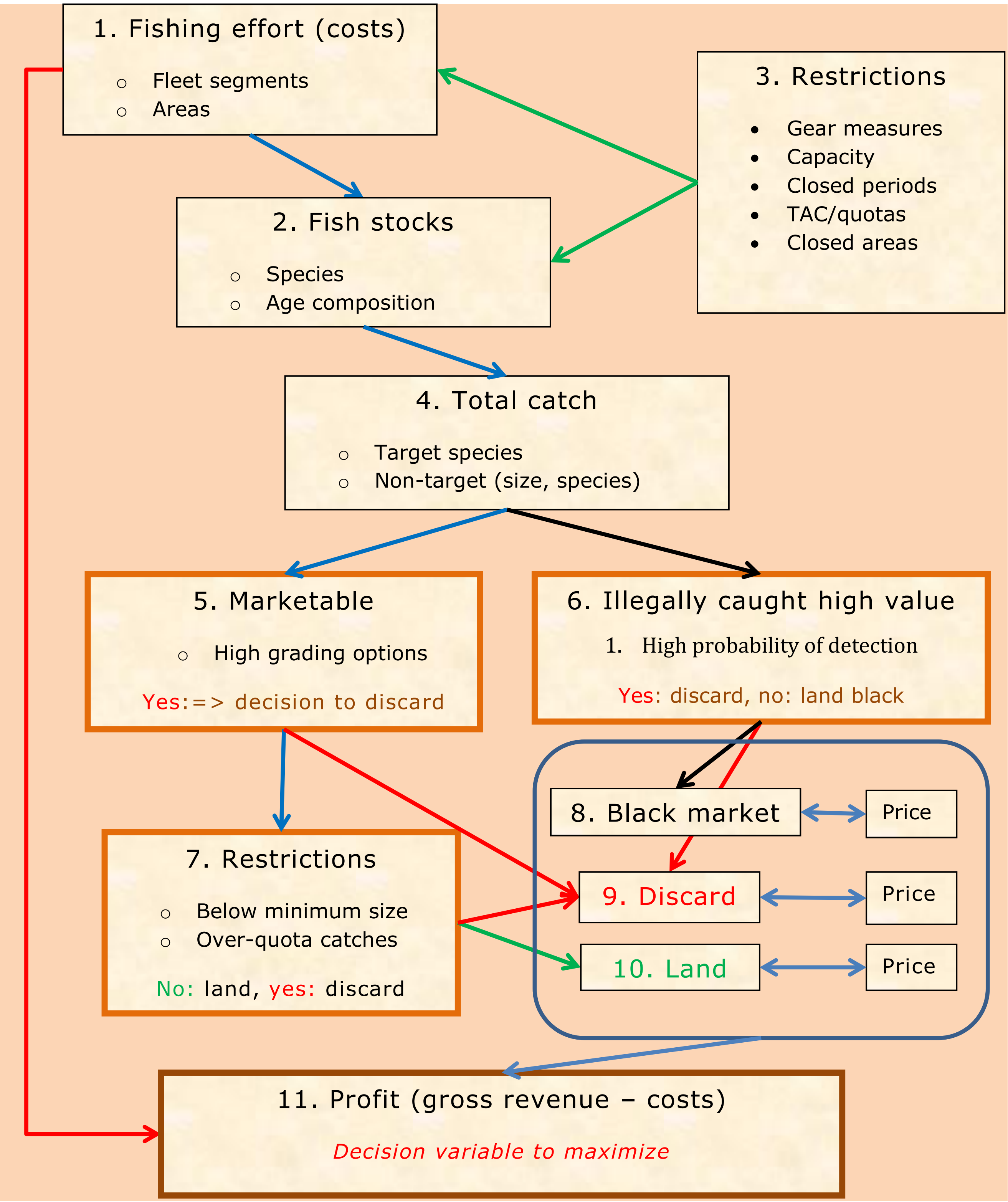


Figure 1. Fishermen's behaviour

If the system is considered *after* the discard ban is introduced the first item to address is how this ban is introduced i. e. which species are included. The underlying incentives for the fishermen will not change but they are influenced by change in the restrictions. In a fully implemented and enforced system there is no illegal fishing and all catches of fish below minimum size and above the quotas are landed. It means that the arrows from box 4 to 6 and to 8 and from box 5 to 9 and 7 to 9 are removed. It is then assessed how profit (box 11) is affected.

The problem is that because the underlying profit maximizing incentives of the fishermen are not changed but only influenced, the cost of monitoring and enforcement of the new regulation will increase. If these costs are covered by the Government, fishermen will adjust their effort subject to maximization of profit, see section 3 for further elucidation of the compliance issue.

The incentives to discarding fish are caused by natural and institutional constraints imposed on the fishery (FAO 1996b). Four general types of constraints are easily identified, see Nordic Council of Ministers (2003):

1. Institutional i.e. management measures defined by managers e.g.
    a. Quotas, effort restrictions, individual transferable quotas
    b. Minimum size on fish
    c. Mesh sizes in fishing gear
2. Biological e.g. species interaction and characteristics of the fish (gender, poisonous etc.)
3. Technological e.g. gear selectivity (prohibited gear, damages to the fish etc.)
4. Economical e.g. price and costs relationships determined on the market including high-grading

From an economic perspective the issue of discarding contains four elements. The first one is the long run perspective from society's viewpoint. This perspective takes into account long run effects on the fish stocks, which is also dealt with here although not in a genuine socioeconomic context using opportunity costs etc. The second one is the short run perspective from society's and the industry's viewpoint. In that perspective stock effects are not included, what is included is the possibility to increase economic benefit to the industry as a whole by reducing discards without taking long run effects into consideration. This aspect is important because society does not always have the same interest as the industry. The third perspective is the fisherman's view. This is important because it deals with the incentive of the fisherman to undertake his fishing activity in a way that is acceptable for society in the short run as well as in the long run. Finally, the fourth perspective is the costs of society that is associated with mitigation of the by-catch problem. These costs include information costs, monitoring and enforcement costs. The last issue will not be considered here. Calculations of economic consequences of reducing discard require:

From fisherman's point of view short term losses counted against long term gains are important but relative large weight is put on short term changes relative to long run changes as the fisherman's time horizon is relatively short (5-10 years). The fisherman must adhere to financial conditions set by society. Society's calculation are based on real economic changes which implies that other price and cost information compared to the fisherman's are used, e.g. society put less weight on short term changes compared to long term changes and has smaller risk, society consider redistribution consequences, society faces entry/exit benefits and costs from the fishing industry relative to other industries etc. Elucidation of economic consequences is helping in the selection process of proper regulatory measures.

To conduct analyses the following type of information (data) is required:

1. Prediction of the long term development of the stocks and hence possible catches (estimates).
2. For the fleet segments short run information (available):

   Catch composition (landable and discardable fish)

   Fish prices

   Direct fishing costs per day

   Cost of discarding including handling costs on board (estimates)

   Fishing area distance relative to landing port (estimates)
3. For the fleet segments long run (estimates).

   Possible change in effort and distribution and hence variable and fixed costs

   Possible change in catches and species composition

   Possible change in prices

It is concluded that knowledge gaps exist with respect to conducting genuine socioeconomic analyses. Financial information is available from statistical sources collated in the EU data collection framework (DCF). As discarding of fish below minimum mesh size used to be compulsory very little data exists about the magnitude of discarded fish. Some data is collated from samples and some is estimated. This knowledge gap is severe, but the economic analyses about fishermen's behavior in section 3 may help to elucidate the magnitude of discarded fish assuming that the fishermen want to maximize their profit.

3 Peer reviewed articles and theoretical outline of discard behaviour

Discards of fish have been subject to concern for many years and this concern has appeared in international fisheries conventions since the 50'es and 60'es, e.g. The North East Atlantic Fisheries Convention (NEAFC). Renewed interest for research about mitigating catches of unwanted species took place from the beginning of the 90'es. Based on biological research results numerical economic analyses about fishing gear changes (mesh sizes and panels) are found in Flaaten and Larsson (1991), Frost (1996), Christensen (1996), and Pascoe and Revill (1999). A conference about discard was organized by FAO in Japan in 1996, (FAO 1996a and 1996b and Clucas 1997). In an FAO context an overview of the economics of discarding could be found in Pascoe (1997) with an update in Kelleher (2005). A workshop in 2002 with participants from the Nordic countries (Nordic Council of Ministers 2003) investigated incentives to discard and options to reduce it. An EU Framework 7 project, NECESSITY, (Frost *et al* 2008) investigated results, based on trials, of reducing discard by using increased mesh sizes or panels, and parallel to that a Danish study took place in 2008 (Kronbak and Vestergaard 2013).

Parallel to the empirical research theoretical work in a socio-economic context is developed. It is useful to distinguish between two approaches in the theoretical work. One approach is about unwanted catches i. e. non-target species in open access and ITQ managed fisheries (Boyce 1996 and Turner 1996 and 1997). This work is in line with the empirical work mentioned above. The economic models used for analyses usually includes two species (target and non-target) and two fleets exploiting both species in the target non-target case and one species i.e. the non- target species for the first fleet. The analyses then deals with the optimal use and allocation of effort subject to a profit (or resource rent) maximizing objective. In such a context by-catches of non-target species constitute an endogenous externality i.e. an outside impact that can be influenced by the fishermen. In a very simple situation with harvest of a target species and a non-target species in fixed proportions fishing effort used on harvesting target species can simply be scaled up and down to reach a first-best optimum. However, harvest may take place in variable proportions and here Boyce (1996) compare open-access, ITQs and joint maximization of the welfare of both species by the two fleets. Open-access in a fishery for the target species leads to excessive by-catches and an ITQ system can only secure a first-best optimum if these are imposed on both target species and by-catches. Segerson (2007) extend the analysis in Boyce (1996) to include stochastic by-catches and show that neither landing fees nor ITQs on both target species and by-catches can secure an expected first-best optimum. A different approach to analyze by-catches is adopted in Abbott and Wilen (2009) where actual regulation, and not optimal regulation, is introduced. Here a given fishery is regulated with total quotas for both species combined with limit entry programs and it is shown that this actual regulation generate excessive by-catches and too short harvest seasons.

The other theoretical approach is dealing with high grading, which is defined as discard of low value fish in order to maximize profit by making room for more valuable fish. As such, high grading will not take place until certain restrictions become binding. Both Arnason (1994) and Anderson (1994) show that a traditional ITQ system only make the incentive to high-grade stronger. However, Turner (1997) shows that a value-based ITQ system secures a welfare optimal level of high-grading like open-access. While it seems obvious that fishermen high grade in order to make the best possible use to him of the quota it seems less clear why he want to high-grade under open access or effort management. The reason is apart from an individual quota also the hold and processing capacity onboard the vessel and the distance between the fishing ground and the port put restrictions on the behavior of the fishermen. In that respect it seems clear that limited hold or processing capacity can be increased in the short run for high priced fish if low priced fish is discarded. In the same way it can pay to make one or two more hauls per trip and discard low valued fish because that is cheaper than going all the way to the port to unload (turn-around-cost), see Vestergaard (1996).

Although the objective for both approaches (target, non-target and high-grading) is to maximize profit the restriction to which maximization takes place is different for the two approaches in the economic models. While target non-target analyses requires (at least) two species and benefits from (at least) two fleets in order to analyze interactions between stocks and fleets, analyses about high-grading requires only one species and one fleet. However, high-grading analyses require inclusion of high and low priced fish. Inclusion of age-structured fish stocks in the model is useful but not necessarily a condition. It is necessary, though, to include two parts of a stock: a low priced part and a high priced part. In that respect the analyses bears resemblance to the target non-target analyses. A more important difference between the two approaches is the weight that is place on various restrictions. In this context it is worth noting that the models described in section 4 uses the target non-target approach rather than the high grading approach.

Fishermen's incentives to discard are in generally small and much discard are caused by the imposition of management measures such as minimum size on fish and quotas in multispecies fisheries. A formalized exposition of what is behind and happens in item 11 in figure 1 may help to highlight the behavior of the fishermen in their search for profit maximization. A formal model about fishermen's behavior in a fishery subject to regulation is found in e. g. Clark (1980). The following exposition is not mathematically completely consistent as the aim is to highlight incentives and decision rules about discarding behavior. Consistent formal expositions of discard behavior tend easily to get very complicated and hence some overview is lost. The following exposition draws upon Andersen *et al* (2014).

Assume first that there is no distinction between fish. All that is harvested is landed. One type of fishing vessel (homogeneous vessels) and one species is assumed. This starting point is for comparison. At a later stage this is divided into large fish meant for human consumption (landable fish) and small fish not eligible for human consumption (discardable fish). The harvest, h, is the product of a constant catchability coefficient, q, standardized vessel effort, E, and fish biomass, x:

$$h=qEx \qquad (1)$$

Having only one species and homogeneous vessels then in a model without discards the model doesn't differentiate between landings and catch but in reality landings will almost always equal catch minus discards (or unwanted catch). Therefore, discards (d) are greater than zero.

In the simplest case for modelling discards explicitly, harvest, h, can be divided into landings, l, and discards, d, that are defined by different catchabilities, q, which depends on the gear technology. q is also a measure for harvest in fixed proportions. In this case Boyce (1996) is followed (target, non-target approach) although only one fish stock and one fleet are included:

$$l=q_lEx \qquad (2)$$

$$d=q_dEx \qquad (3)$$

The profitability of a vessel can be calculated (Clark 1980) saying that each vessel's profit is a function of fish stock abundance and effort:

$$\pi = \pi\,(E,x) = (p_lq_l+p_dq_d)\;xE-cE \qquad (4)$$

where price, p, is different for landed and discarded quantity. Discard will only take place if p_d (actually the marginal profit) is negative i. e. the fisherman will have to pay to sell the fish. This may happen is the fish is damaged. It is assumed that costs are linear to effort E, which is a reasonable assumption as the fishing industry is small compared to other industries and may, therefore, extract inputs at constant unit costs. Costs are not differentiated for landable and discardable fish. As the fishermen cannot control the stock abundance x they only adjust effort is such a way that profit is maximized. Max profit is found by differentiating (*4*) with respect to E:

$$\text{Max profit: } (p_lq_l+p_dq_d)\;x = c \qquad (5)$$

With reference to section 2 incentives to discard are, largely, caused by regulatory measures (Figure 1, box 3) for reasons of biological and technical interaction a pure selective fishery is impossible even for one species where catchability and price differ for various sizes of the fish. It is costly to handle i. e. to catch, to gut and clean, to grade, to store and to bring the fish on the quay. Therefore, the fisherman may consider maximizing his profit and avoiding these costs simply by discarding fish. On the other hand revenue is lost but if the revenue is smaller than the costs of handling then it would pay to discard. To investigate this we assume that the cost of handling discards is proportional to the amount of discards, which makes it possible to define two separate handling cost functions, one for handling of landings and one for handling of unwanted (with a potential to be discarded). This means that equation (4) is modified. For simplicity it is assumed that costs are linear in landings and hence in our case is linear in E:

$$c_{hl}(l)=c_{hl}l \text{ and } c_{hd}(d)=c_{hd}d \qquad (6)$$

where the foot signs, *hl*, and, *hd,* stand for 'handling landings' and 'handling discards'. Consequently, c defines pure catching and steaming costs. The argument for this distinction between cost types is that fishermen cannot distinguish between species when they trawl or set the net. However after the harvest is bought on board a distinction is possible. Therefore, maximizing profit taking into account the costs of landings can be defined as:

$$\text{Max profit: } ((p_l - c_{hl})\, q_l + (p_d - c_{hd})\, q_d)\, x = c \qquad (7)$$

Looking at the left hand side of (7) it is assumed always that $p_l > c_{hl}$. It is noted that if $p_d < c_{hd}$ and fish with a potential for discarding (i.e. undersized or in other ways unwanted catch) cannot be caught separately then this fish will be discarded. If $p_d > c_{hd}$ then the fish will be landed in this simple case.

The catch of unwanted fish can be controlled through a change in catchability, q_d, i. e. the level of technology investment and effort applied e. g. improved gear selectivity and change of fishing grounds. A change in q will change the catch shares between the species. Taking an example of investing in a wider mesh size then less fish including discardable fish is caught. Therefore it can be approximated that catchability of fish with a potential for discard is a function of effort:

$$q_d = q_d(E) \qquad (8)$$

It can be assumed that catchability of discards will follow the same trend as catchability of landings i. e. that as the catchability rate decreases then effort increases, $\partial q_d \,/\, \partial E < 0$. If effort goes up costs will increase and then effort which is required to maximize profit goes down compared to the case before improved selectivity. An exogenous change in selectivity will not secure an economic optimum.

Now another type of cost is introduced. So far costs of discarding have been disregarded. Instead of handling the unwanted fish in the net the fish could be disposed of instantly either by slipping them out of the net before taking the fish onboard, or throwing them overboard at once they are on deck. It can be assumed that these costs, c_d,, are very low if the fish is discarded instantly after it has been brought on deck or even slipped out of the nets before being brought onboard.

As stated above if $p_d < c_{hd}$ then the fish should be discarded. However, it may pay to land fish even when handling costs are higher than the price. If costs of discarding are higher than the loss by landing, $c_{hd} - p_d < c_d$, then the fish will be landed. Discarding will take place in case net loss from landing the fish is higher than costs of discarding, c_{hd} - p_d > c_d. The profit function is as (5) in case of landing, but in case of discarding it is:

$$\text{Max profit: } (p_l - d_l)\, q_l x - c_d q_d\, x = c \qquad (9)$$

If it is made illegal to discard fish and the condition for discarding, $c_{hd} - p_d - c_d > 0$, apply, monitoring and control must be invoked on the fishermen as a penalty to induce them not to discard (Sutinen and Andersen 1985). When it is difficult to monitor and control fishermen's behavior at sea fishermen may derogate from regulation. Jensen and Vestergaard (2002) considered discard in a moral hazard context i. e. when fishermen hide their actions at sea and as these actions cannot be detected repercussions are place on fishermen based on common elements such as estimated fish stock changes. This type of management uses a sort of common punishment similar to what is used in the insurance area. Fishermen could be motivated to reveal their hidden actions by giving them a discount on the common penalty.

In some communities people will comply with regulation without notice but in other communities some influencing of behavior is required in terms of command and control or penalties (Sutinen and Kuperan 1999). In theory, a penalty can be introduced in various ways for example as an increase in c_d or in p. It could also be invoked as a penalty placed on the (estimated) net befit from discarding. The fisherman will include the penalty, ρ, in his decision function. However, he will also take into account the probability, θ, of being detected. A penalty can be imposed in different ways either as a fixed amount or a function of the seriousness of the offense. If the penalty is a function of the (estimated) benefit from discarding then discarding will take place if ρ and θ are chosen in such a way that the left hand side is larger than the right hand side i. e. inequality (10) holds. In other words if the risk of being detected and the penalty is low fish will be discarded.

$$(1-\theta)(c_{hd} - p_d - c_d) > \rho\theta(c_{hd} - p_d - c_d) \qquad (10)$$

The fisherman will discard and his max profit condition is as (7). If the inequality sign in condition (10) is reverted (right hand side larger than left hand side), then the fisherman will land, and this is controlled by the magnitude of the penalty and the probability of being detected.

With reference to, in particular, Arnason (1994), who presents a formal derivation of the subject two more issues need to be addressed. One is: what is the impact on discarding under free competitive access and under and ITQ management. Note that ITQ management with respect to discard incentives corresponds to a hold restriction for the vessel. The other one is: what is the impact of discarding on stock abundance and do fishermen take that into account. In depends on whether the discard is written off the quota or not. If it is it will be taken into account and hence the probability of being detected will also apply.

With reference to the decision rule for discarding, c_{hd} - p_d > c_d, or rearranged $c_{hd} > c_d + p_d$ saying that if the landing costs are higher than the costs of discarding plus the foregone earnings then it pays to discard. In an open access competitive fishery this will be the decision rule. From the fisherman's point of view the impact on the stock does not count, therefore discarding will be optimal when the rule applies. However, if the fishery is subject to ITQ management, the ITQ (and the same applies for lack of space in the hold) represents a value to the fisherman and he will take changes in that value into account, when he plans his fishery. Now the new decision rule is $u + c_{hd} > c_d + p_d$ where u is the marginal value of the ITQ (or hold space) to the fisherman. Basically it implies that the incentive to discard increases under an ITQ management system. The explanation is that the individual quota represents a value to the fisherman. Hence if he lands this value is lost, as the quota could be sold, and therefore landing represents a further cost to him.

What about the impact on the biomass in this case. In an ITQ system the fisherman has some influence on the stock size. If he does not use the quota the stock abundance will increase and this will usually represents a positive value. Let the marginal value of the stock to him be denoted, s, then this value must be subtracted from the quota effect. Therefore the decision rule is in this case $u - s + c_{hd} > c_d + p_d$. Usually there is little empirical evidence for the magnitude of u and s.

Finally, a few comments are made about the impact on discarding of the distance between the fishing ground and the port (Vestergaard 1996). If the fishing ground is very far from the port the steaming time between fishing ground and port becomes important as it reduces the effective fishing time and hence catching opportunities of fish for human consumption. If the hold capacity is fully used and when this lost opportunity is taken into account in the decision rule it translates to $v(p_l - c_{hl}) + u - s + c_{hd} > c_d + p_d$ where v represents the distance to the fishing ground.

To summarize it can be said that the incentive to discard depends on:

- Species composition in harvest
- Price on fish
- Processing costs on board the vessel
- Catchability rates
- Discard costs
- Penalty for violation of rules
- Probability of being detected
- Management system
- Impact on stock abundance
- Distance to fishing grounds

Basically, the decision about discarding is simple: If the sales price of the fish is smaller than the handling costs, then the fish will be thrown out as it represents a loss to the fisherman. This information is usually easily available to the fisherman and in most cases the cost of throwing out the fish instantly (discarding costs) is small. Including the discarding cost and assuming they are of some magnitude it pays to discard the fish if the loss by landing the fish is higher than the cost of discarding. As indicated above there is, however, a long list of elements that need to be taken into account including the type of management and the probability of being detected if the fishermen want to maximize the profit from fishing.

It is clear that if the species composition in the harvest and the fishing technology does not fit the way the fishery is managed fishermen will discard according to the regulation. In addition to that the general conclusion is that incentives to discard are small unless the price on discardable fish is very low and the handling costs high. However, the incentives to discard increases with large price differences between landable and discardable fish, with non-transferable and transferable quota management , if the hold capacity onboard the vessels is restrictive and if the distance to the fishing ground from the port is long. All these conditions are seldom fulfilled. It must be taken into account that every time fish is discarded effort is required to “re-catch” fish and if the share of landable fish is low compared to discarable fish these costs are high. If the share of landable fish in the catch is high there is little fish to discard. This conclusion is supported by numerical examples, (Anderson 1994, Arnason 1994, Nordic Council of Ministers 2003, ch. 2.4, and Committee to Review Individual Fishing Quotas 1999, Box 3.4, p 109).

The impact on the stock abundance of discarding fish is worth noting. If the discarded fish do not survive there is no positive impact on the stock. To obtain such an effect it is necessary to avoid catch of these fish either by change of fishing ground or by stop in the fishery i. e. by redistribution and/or a decrease in fishing effort. If the discarded fish die or if there is a landing obligation for discardable fish there is no positive impact.

The literature survey above shows that almost all analyses about optimal discarding behaviour are based on static models and an assumption about maximization of profit. There are no restrictions in terms of minimum sizes on fish and mesh sizes in fishing gear in these analyses. With the introduction of landings obligations restrictions are imposed, which impacts the behaviour of fishermen and hence the adjustment. In terms of static model analyses landings obligations change the parameter values of the equations, which impact the optimal solution. In particular lower costs of surveillance on board increases the probability of being detected and hence lower the incentive to discard. This could lead to increased incentives to develop new fishing technologies and changes in the allocation of effort in space and time in order to reduce unwanted by-catch. If the fishing mortality is reduced by these changes it will impact the fish stock abundances. Such development is best analyzed in dynamic multispecies multifleet models, see section 4.

When economic theory is combined with complex dynamic simulation models of which management measures form an integrate part the capability of answering questions with respect to change in management e. g. such as landings obligations increases significantly. Such models make it possible to address a number of topics in a dynamic way, which is generally out of reach in simple models that are designed to demonstrate equilibrium solutions and not the dynamics towards equilibrium.

As a supplement to static equilibrium models the advantages of complex dynamic simulation models are many. Seminal papers analyzing the dynamics of fisheries including entry and exit of fishing effort are Smith (1968) and (1969); Clark and Munro (1975), where the latter argue that more insight are gained from using dynamic models compared to static.

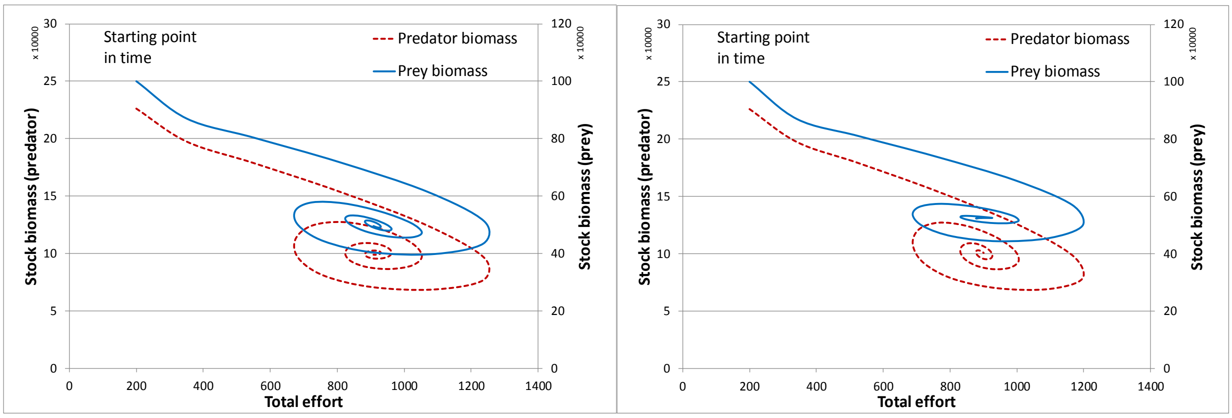
Firstly, the very detailed format of such models makes very detailed analyses possible. Secondly, the complex format increases the opportunities of the model for being linked to external elements or models e. g. ecosystem models, which is important as regards the connection to WP1. Thirdly, management actions and fishermen’s dynamic response to such actions can be included in complex models contrary to the simple theoretical models which normally indicate the optimal management measures based on assumption about fishermen's behavior. Fourthly, complex models can simply serve as laboratories (Arnason 2000).

In a complex model working in a dynamic setting, simulations do not necessarily lead to equilibrium solutions. The models used are discrete-time models, the type of which Clark mentions with respect to the shortcomings of the theoretical mathematical models when these are used to analyze more complex problems:

> *"In trying to model these and other complications, we face the danger that our mathematical models may become too complex to be analyzed and understood. One way to try to overcome this problem is to use the computer to simulate complex systems. .... it should be realized that from the scientific point of view the results of such exercises at best serve as illustrations of a general theoretical framework"* (Clark, 2005 p. 197).

It is debatable whether the second part of Clark's statement is correct as the very complex models are impossible to solve analytically and how do we know whether the results from extending the simpler models are still valid? Furthermore, and probably more important is that the theoretical models usually analyse equilibrium solutions. In the real world the fishery is seldom in equilibrium. The complex dynamic simulation models are applicable in such situations for *what-if* analyses, but without a strong theoretical foundation such *what-if* analyses may be of little value. Therefore, the challenge using complex dynamic simulation models is to assess, founded on a theoretical basis, whether the results from a management change such as a landing obligation is better or worse than the situation without the obligation.

An example of the use of a dynamic model derived from Ravensbeck (2014) is shown in Figure 2. The purpose with the figure is to demonstrate the dynamics here by looking at the change in stock biomasses and fishing effort (phase diagram). The fishermen "control" the system by their investment behaviour i. e. they enter if they make a profit and leave if they experience a loss. The model includes two species, a predator and a prey species, and two fleets of which one target only the high valued predator and the other on target the low valued prey with a small by-catch of the predator. For this fleet the predator is expensive to land and, therefore, the choices are to discard the predator at low cost or to land it at high cost. In this particular case the fishermen of fleet 2 choose to discard, if this option is possible. The fishery starts from a situation with no exploitation and there are no other restrictions on the fishery apart from the landing obligation (vs. discarding of fish).



Forced to discard

Forced to land

Figure 2. Phase diagram. An example of use of a dynamic model for a computation of consequences of discarding behaviour and landing obligation

With the chosen assumptions, among those a fixed share between catches of prey and predator for fleet 2 and open access to and departure from the fishery, the phase diagram show the combination of stocks and effort over time. In this particular example the fishery moves towards equilibrium after many years, and the difference between the two scenarios is not big. However, this picture may change rather dramatically once further restrictions are placed on the fishery e. g. TAC, entry restrictions etc. The models described in section 4 are extensions of the modelling framework underlying figure 2.

This also brings up the question of the compliance regime which is not discussed in much detail in this context. Developing an effective compliance regime that is also cost-effective will probably be the most important determinant of whether the landing obligation is successful or a complete disaster. Compliance and monitoring and some policy and institutions work are dealt with in later work products and deliverables, but it good to keep this mind now and think about whether and how the models and analyses that will be performed can take these institutional and dynamic factors into consideration.

Finally, a few words are made on the dynamic economic models capabilities in the area of ecosystem management, which is pertinent with respect to the link to WP1. The references are kept separate in the list of references (section 5) and are based on the Ph.D thesis of Ravensbeck (2014).

Over the last two decades ecological economics (Daly and Farley 2004) and ecosystem assessment and management represented by the Millennium Ecosystem Assessment (MEA 2005, Fisher and Turner 2008) have attracted great attention. From an economic point of view these disciplines challenge parts of the conventional economic disciplines.

There is a difference between the views of economists and ecologists as to how to define ecosystem services, and the importance of each of them (Boyd 2006, and Boyd and Banzhaf 2007, Fisher and Turner 2008, Bateman *et al* 2011, Balmford *et al* 2011). The general principle in economics is that only the end product is of importance to the consumers and should be counted while all intermediate products should be disregarded as they are embodied in the final product. This means that assets in terms of fish stocks, forests, land, oil resources etc. are of no value by themselves if they are not demanded or valued by consumers. The Millennium Ecosystem Assessment comprises a list of ecosystem services, but many of the services listed in the MEA (2003) are of indirect importance according to this point of view. Ecologists view is, in general, that these assets hold a value irrespective of being exploited or not.

In recent years, both provisioning of ecosystem services, such as catch of fish, and regulation and cultural services consisting of habitat maintenance and non-extracting recreational activities have been included in the models (Kellner et al. 2011). Similarly, models have been elaborated to incorporate the impact of ecosystem externalities (negative or positive) created by the fishing activities (Ryan et al. 2014). There are several other ways of integrating economic and ecological aspects (Kellner *et al*. 2011, Hannesson and Herrick 2010, Finnoff and Tschirhart 2008, Jin *et al*. 2012), Gascuel *et al*. (2012).

Drechsler *et al*. (2007) examined the differences between the modeling approaches in economics and ecology by assessing 60 randomly selected models that looked into biodiversity conservation issues. The models were classified as mainly ecological, mainly economic or as integrated ecological-economic models. The economic models tend to be relatively simple and typically avoid aspects of space, dynamics and uncertainty, and they apply analytical methods. They often use simple assumptions, whereas ecological models typically are more complex and often apply simulation. The latter are rather specific and frequently include dynamics, space and uncertainty. However, they often ignore economic and institutional issues. The integrated ecological-economic models are regarded as having intermediate complexity. Ecosystem models have been developed that aim at modeling the entire ecosystem, such as Ecopath with Ecosim (Christensen and Walters 2004 and 2011) and Atlantis (Fulton 2010). Another approach is to link a bioeconomic model with an ecological model to analyse whether the estimated optimal fishing level is within sustainable limits (Lassen *et al*. 2013).

Standard bioeconomic models do not assess how harvesting impacts the biodiversity and ecosystem services (Tschirhart 2009, Perrings 2010). Over the years, efforts have been made to make models that better reflect the complex reality by including additional species or other values than the fishing-related in the models.

Generally though, more complex settings are required for ecosystem-based management (Arkema *et al*. 2006). The general objective of ecosystem-based fishery management (EBFM) is to avoid degradation of ecosystems and to consider requirements of non-target species, protected species, habitats and take trophic interactions into account (Pikitch *et al*. 2004 Holland *et al*. 2010). Marine ecosystem-based management furthermore includes the activities of other sectors (Arkema *et al*. 2006, Curtin and Prellezo 2010). According to Fogerty (2014), an ecosystem-based fishery management (EBFM) should incorporate interrelationships among the different elements of the system, include humans as an integral part of the system and cover the effects of environmental influences. EBFM differs from the ecosystem approach to fishery management (EAFM) which has its focus on individual species or stocks. Ecosystem-based management will require knowledge about the quantitative relationship between stocks of different species. These interconnections influence the ecosystem services and subsequently these services can be assessed economically.

4 Models

Models that comply with economic theory and are applicable with available data are selected for the assessment of the economic repercussions of the landings obligation. Peer reviewed articles often deal with theoretical issues, develop and use specific models and do not depend on empirical data. On the other hand, the grey literature is often descriptive and empirical and use models often complex and holistic in nature.

The International Council for the Exploration of the Sea (ICES) set up a study group on "Integration of Economics, Stock Assessment and Fisheries Management" (SGIMM). The first report by the group was published in 2011. This study group has been renamed in 2015 to the Working Group on "Integrating Ecological and Economic Models" (WGIMM), chaired by Jörn Schmidt, Germany, J. Rasmus Nielsen, Denmark and Eric Thunberg, USA. The group has covered a description and evaluation of all known operating large bioeconomic models used for assessment of economic, biological and lately also ecological repercussions (Nielsen et al., 2015). Twenty six models are included. Some of them are similar in structure but applied to different fisheries (data sets). The models are evaluated with respect to i) coverage, ii) management advice capabilities, iii) implementation areas, and iv) level of model development plus some other item not relevant for discard assessments. A general problem with complex models is that usually they are not user friendly. A certain expertize is required to operate the model in a safe way so that the results are trustworthy. This aspect is taken into account in our choice of models.

The models chosen for evaluations in Discardless tasks 2.3 and 2.4 are selected from the above mentioned criteria including the special level of knowledge to the models by the participants. The selected models are:

Fishrent (North Sea – Danish demersal fishery), in operation since 2010

LOEB (Development of Fishrent) (West of Scotland), in operation since 2015

FLBEIA (Bay of Biscay and Celtic Sea) , in operation since 2011

MEFISTO (East. Med. Sea and West. Med. Sea), in operation since 2002

Fcube (optional), in operation since 2008 as regard biological component, extended with economics since 2010

ISIS-Fish (Eastern English Channel), in operation since 2004, with fleet dynamics and economic components since 2009.

In addition to that, particularly, with reference to gear selectivity and reduced discard are two specific modelling work developed in the EU project NECESSITY (Frost, H. et al. 2007) and a DK-government project IMPSEL concluded in 2007 (Kronbak and Vestergaard 2013).

The selected models are thoroughly described in papers and reports elsewhere. Therefore only a brief description is provided here with emphasize on similarities and differences. All models are:

1. Dynamic and discrete e. i. work over time (one year step) with changes in both fish stock and fishing fleets.

2. Includes a number of (different) features to assess implications of various management measures. These features are generally de-activated in Discardless as they are outside the scope of Discardless except for TACs and quotas.
3. The models are constructed in modules covering different aspects of the fishery system. An exposition is found in figure 3. The arrows show the direction of impact. Note, policy can only impact the Biological box indirectly.

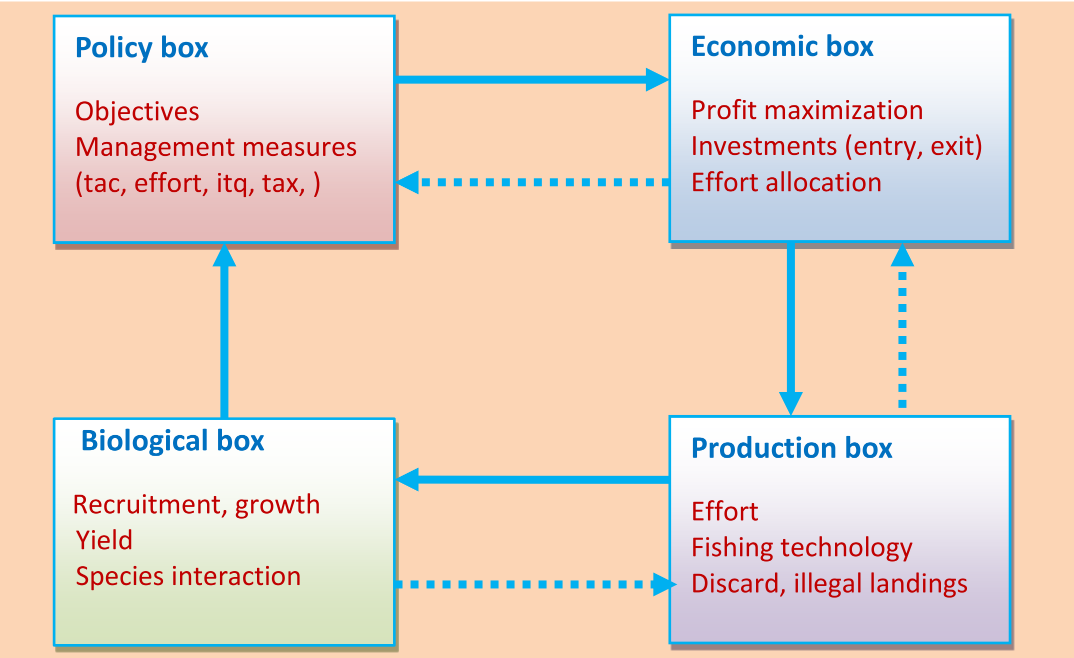


Figure 3. An example of modules in a bioeconomic model.

Fishrent (Salz *et al* 2011, Frost *et al* 2013) includes all four boxes. In the biological box fish stocks are included as aggregate stock and recruitment and growth of the stock is a function of the size of the stock. The recruitment function is logistic (sometimes referred to as Gordon-Schaefer recruitment) but could also use Ricker or Beverton-Holt recruitment as well as constant recruitment. There is no species interaction in Fishrent, but stocks are affected by the Production box by the fishing technology and effort by the species compositions determined by these factors. Hence in order to produce landings (to the Economic box) discard of fish and illegal landing may be regarded as production factors which are necessary as they are linked to the effort and the fishing technology. The Economic box includes the behavior of the fishermen as they seek to maximize the profit by determining entry and exit, which affects fishing effort etc. The Policy box is of minor interest. However, in that box the decision of landings obligations for all catches impact the behavior of the fishermen (Economic box) though the way they enter and leave the fishery, and how they exert effort and chose fishing technology. Eventually these choices affect the Biological box. Fishrent is programmed in Excel and in GAMS (the latter must be purchased and is, consequently, not immediately accessible).

FLBEIA (Garcia *et al* 2010) also includes all four boxes. The Biological box, however, is organized with age structured fish stocks, which comply with biological population analyses as conducted by e.g. ICES.

For stocks which are not subject to analytical assessment FLBEA also accommodates aggregate stocks and recruitment, which could be of Ricker or Beverton-Holt types as well as constant recruitment. The age structured biological component allows for more detailed calculations as regard catch of small fish compared to Fishrent but is also more data demanding in that respect. The Production box and the Economic box are organized very much as in Fishrent. Both apply Cobb-Douglas production functions to determine catches as a function of fishing effort and stock size and both apply investment functions (entry exit of vessels) which are specified in the same way. Cost is a function of the production factors in the C-D function. Both models also use the same type of price formation function, which by use of flexibility rates determines prices as a function of landings. Prices could also be constant but vary with respect to gear type, which determines the size of the fish e. g. trawl target usually smaller sizes at lower prices, while gill net target larger fish at higher prices. FLBEIA is programmed in R using FLR objects, which is open source and fits in this respect directly to the stock assessment output produced by e. i. ICES. A further comparison between Fishrent, FLBEIA and Fcube is found in Jardim *et al* (2013).

MEFISTO 3.0 (Lleonart *et al* 2004) was developed by the biologist Lleonart, the economist Franquesa and programmed by Maynou. The model has formed basis for later extensions e. g. BEMFISH and MEFISTO 3.0 is the result of developments from earlier versions. The model's Biological box is basically constructed as an age structured fish stock component. If data is short aggregate fish stock biomasses are used. The Production box is similar to Fishrent and FLBEIA, but the Economic box differs as catches are based on application of fishing mortality rates (F) like in conventional biological models and not an economic production function. Fishing mortality rates and fishing effort, E, is linked by a linear function in which, F is a function of E. E changes over time and hence F will change. Catches are then calculated directly from the Biological box and then transferred to the Economic box after multiplication with fish prices. The catches, which are the total catches of the relevant stock, is then allocated to the fleets (effort) in proportion to the relevant fleet segments catches share of the total catches. Basically it means that the functional form of the production function is different from the ones applied in Fishrent and FLBEIA. However, one must have in mind that the output of the production functions is also dependent of the estimated parameters of the functions. Cost is a function of fishing effort and when these costs of the pertinent fleet segment are subtracted from the allocated revenue to the segment the resulting profit determines the investment. In MEFISTO investment is also dependent on access to loans from banks and in this way MEFISTO 3.0 also differs from Fishrent and Mefisto. MEFISTO 3.0 is programmed using Borland's Delphi 6.0. Currently, the software is being ported to Linux using Borland's Kylix 2.0, which is an open access source and can be downloaded either from CD or the web.

Fcube (Ulrich *et al* 2011) can rather be characterized as being a frame or general approach to mixed-fisheries modelling, rather than a fixed model. The core of FCube is a R-FLR (Kell *et al* 2007) function linking fishing opportunities with fishing effort in mixed-fisheries, and that function can then be integrated into any modelling setup, according to the questions asked. It is continuously being expanded, being for example able to run short or medium term, deterministic or stochastic, with our without economic outputs etc. Fcube can be considered together with FLBEIA, since both models build on the same data format and ideas. So in principle the two models can easily be operated conjointly, as is being successfully shown in the Celtic Sea. The model is currently annual and non-spatial. Unlimited number of fleets, metiers and stocks can be imputed. All implemented in R/FLR scripts and functions. Standard international datasets are used: Single stock assessment and advice, but can be also adapted to stocks without analytical assessment. Fcube use fleet and metier catch and effort data as available from e.g. ICES InterCatch, STECF databases or directly from national institutes. DCF Economic data is used. An early version of Fcube was amended by an economic component FcuEcon (Hoff *et al* 2010). The amendment consisted of price of cost information multiplied to the output of catches in the mixed-species Fcube component. The amendment allowed for economic assessment of three options used in Fcube: MIN, MAX and MAX value. In the MIN-case the fishery stops once the most binding quota (species) in the mixed fishery is exhausted. In the MAX- case the fishery continues until the least binding quota is caught. This, obviously, results in over-quota catches of infra-marginal species. In the MAX-value case quotas are determined in such a way that the profit is maximized. This implies that some quotas are overexploited and some are underexploited.

ISIS-Fish is a deterministic fisheries dynamic simulation model designed to investigate the consequences of alternative policies on the dynamics of resources and fleets for fisheries with mixed-species harvests (Mahévas and Pelletier 2004; Pelletier et al, 2009). It allows quantitative policy screening of combined management options, such as total allowable catch (TAC), effort control, licenses, gear restrictions, MPA, etc. Fishing mortality is the result of the interaction between the spatial distribution of population abundance resulting from the population submodel and the spatial distribution of fishing effort provided by the exploitation and management submodels at a monthly time-step. Fishing effort is standardized per métier and fleet according to gear selectivity and efficiency, ability to specifically target a species and technical efficiency. The effect of management measures can therefore be explicitly modelled either through modifications of the standardisation parameters for technical measures (e.g. change in the selectivity curve) or through modification of the level and spatio-temporal distribution of fishing time for seasonal closures or effort control for instance. Fisher's response to management may be accounted for by means of decision rules conditioned on population and exploitation variables or explicit dynamic model with endogenous (e.g. fish prices and variable costs) or exogenous variables. Discarding behaviour is implemented through decision rules (by default, as the consequence of catches under legal size or TAC reaching). The model is flexible in its spatial resolution and level of complexity to accommodate the specificities of mixed fisheries.

The reviewed papers and the model expositions in section 3 distinguish between causes for discarding in terms of 1) target, non-target species and 2) high-grading. The economic analyses are aiming at the optimal use of inputs by maximization of profit, privately or socially, subject to a number of constraints. This system affects the behavior of the fishermen. The distinction between items 1) and 2) is not completely clear but while item 1) tends to be biological and technical item 2) is economical and both items are characterized by the different constraints which are in focus in the analyses.

The selected models are designed to work with target and non-target catches and the economic repercussions of changes in these catches. Therefore, they refer to Boyce (1996) rather than to the high-grading analyses (Anderson 1994 and Arnason 1994). Empirical analyses about high-grading on a broader scale are difficult to accomplish as information is required about the hold and processing limitations on board a fishing vessel is required. However, because of the landing obligations high-grading is outside the scope of Discardless and therefore the design of the selected models are appropriate.

As the applied models are dynamic it is possible to demonstrate the adjustment path towards a new state of the system as a result of the introduction of the landings obligations. Inclusion of ecosystem services (MEA 2005) is indicated in Figure 4 and how these services could be linked to the bioeconomic models. The figure is set up according to the DPSIR system (driver, pressure, state, impact, response) to show the cause and impact of the system, see OECD (1994). Data shortage is severe in particular with respect to box 5, and how box 5 interacts with box 3. It should be noted that when management measures are introduced from box 4 it works only through box 1, which is the driver of the whole system.

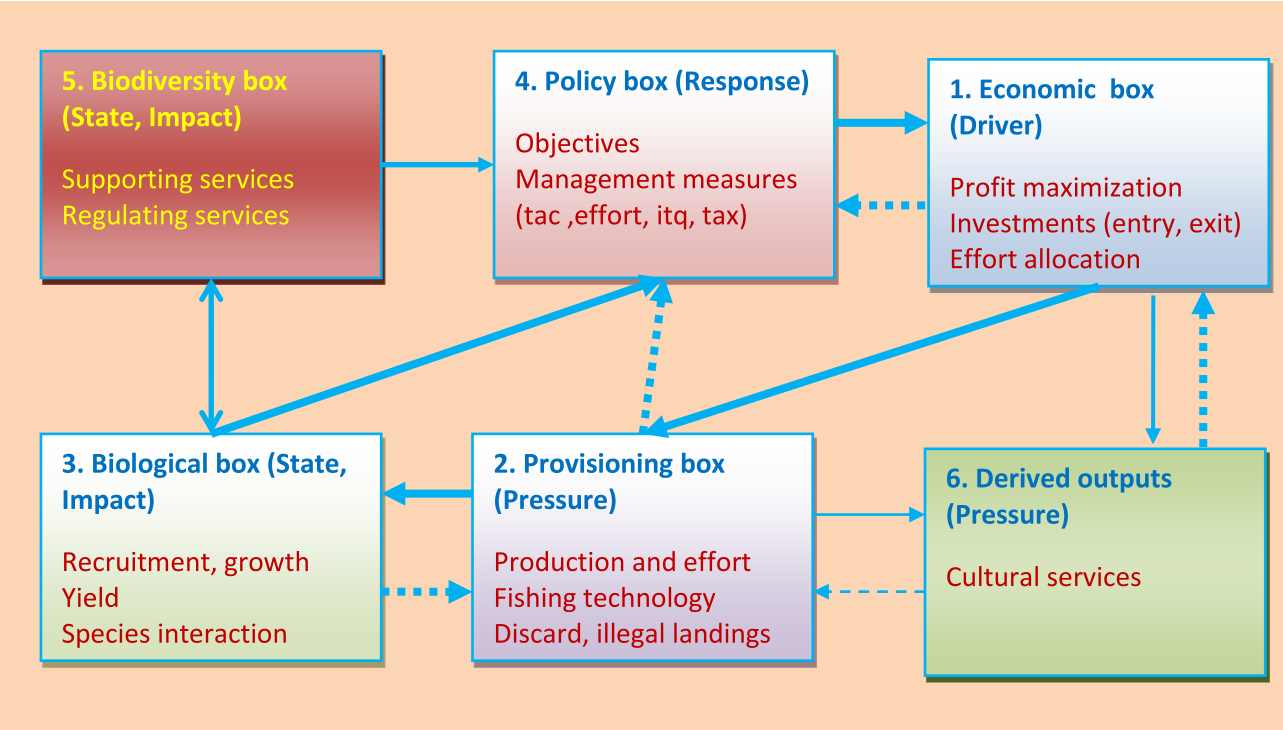


Figure 4. An example of a bioeconomic model linked to ecosystem services

The arrows show the direction of the influence. While policy is influenced of what happens in many boxes the response can only work through one box. It is possible to affect fishermen but it is impossible to affect a harbor porpoise and even more difficult to affect the abundance and "behavior" of zooplankton directly. This means that management of such a system is very indirect and extremely difficult. Although the impact of the ecosystem services is outside the scope of WP2 it is useful to have in mind.

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6 Case Studies

In total nine case studies are chosen. However not all are applicable for WP2 partly because of the objective of the case and partly because of data shortage with respect to carry out economic calculation. The nine cases are:

Azores	Deep Sea Hooks and lines*
Eastern Med.	Mixed*
Western Med.	Mixed demersal*
Bay of Biscay	Mixed demersal*
Celtic Sea	Mixed demersal
Eastern Channel	Mixed demersal*
North Sea – West of Scotland	Mixed demersal
Iceland	Mixed*
Barents Sea	Shrimps

*: includes important small scale fisheries

Of these cases five (1, 2, 4, 5, 6) have been chosen for assessment of economic repercussions of the landings obligation. A common template has been tentatively followed to describe the models in a standardized approach, but not all cases have been equally detailed. The case study of the Eastern Channel will mainly contribute to WP1 but will feed in to economic assessment in WP2. The case studies for Iceland and the Barents Sea will not contribute to WP2 in the same way as the selected five cases but both include economic components.

Case	**Model**	**Handle discard**	**Data**	**National data**
1. North Sea –West of Scotland	Fishrent (Ayoe Hoff, Hans Frost) LOEB (Fishrent development) (Jennifer Russel, Simon Mardle et al.) Fcube (Clara Ulrich) Honeycomb (Coby Needle)	Yes 2) Yes 2) Yes 1) Yes 1)	DCF (STECF-JRC), ICES	DTU-Aqua, SEAFISH
2. Celtic Sea	FLBEIA (Norman Graham)	Yes 1)	DCF (STECF-JRC), ICES	
3. Eastern Channel	ISIS (Sigrid Lehuta, Youen Vermard)	Yes 1)		
4. Bay of Biscay	FLBEIA (Raul Prellezo)	Yes 1)	DCF (STECF-JRC), ICES	
5 West. Med. Sea	MEFISTO (Antoni Quetglas)	Yes 1)		
6. East. Med. Sea	MEFISTO (George Triantaphyllidis)	Yes 1)		

1) Age structured stocks 2) Aggregate stocks

6.1 North Sea, West of Scotland (IFRO, Frost; Seafish, Cowie; DTU-Aqua, Ulrich; MSS, Needle)

IFRO (Hans Frost)

1. **Models/data:**

For each of the (bio) economic models you have knowledge of (in your case study) than can handle/have already been used to evaluate effects of the landings obligation, please fill out the following:

Model name	Fishrent
Case study that the model will/already covers	Danish North Sea demersal fishery
Give a short description of the model (economic components, biological components, multi/single fleet/species, etc.)	Fishrent is described in the section 'Models' above
Which data is needed as input to the model (economic – e.g. STECF, biological e.g. ICES, other)	Cost and earnings data on fleet segment level as required by DCF. Discard fractions as obtained from ICES. National discard data available from DTU-Aqua. Price and cost data from national sources about landings of fish below minimum size, which would have been discarded previously according to the CFP. For a source to these data see: Larsen, Erling P., Jørgen Dalskov, Einer Eg Nielsen, Eskild Kirkegaard, Johan Wedel Nielsen, Poul Tørring og Mogens Schou.2013. Dansk fiskeris udnyttelse af discardforbuddet - en udredning (Danish fisheries exploitation of the discard ban - an elucidation. DTU Aqua-rapport nr. 275-2013
Have the model already been used to evaluate effects of the landings obligation? *If this is the case, please give a short description of this work, including references to reports etc.*	No.
Do you plan to use the model in Discardless (task 2.3+2.4)?	Yes.

2. **Existing knowledge**

For the case study you are involved in, please list reports/working papers/journal articles/other literature/ongoing projects etc. that maps/investigates effects of the landings obligation in your area/CS. For each listed reference, please fill out the following:

Name of reference	NECESSITY (2003-2007) EU's 6th Framework Programme project
Case study that the reference covers	Kattegat. Selectivity in Norway lobster trawl to reduce discard of cod, plaice etc.

Type of reference (Journal paper/report/working paper/project etc.)	NECESSITY. 2007. *Economic Impact Assessment of Changes in Fishing Gear*. Hans Frost, Jan-Tjeerd Boom, Erik Buisman, James Innes, Sebastien Metz, Philip Rodgers, and Kees Taal. Copenhagen FOI report no. 194.
Please give a short description of the work described in the reference (1-2 pages). E.g. what species and fleets are described in the study, how is the study performed (model evaluations, interviews, others), what are the conclusions of the work?	Before and after change in selectivity hence discard computed in the biological part and then imported into the CBA-model. Conclusion. Better selectivity did not result in improved profitability. The model is documented in Chapter 1 in FOI report 194, The framework is available. The model setup is relatively easy to work with. Uses the EU DCF data and ICES stock assessment data.

Name of reference	IMPSEL (2005-2007) Danish project
Case study that the reference covers	North Sea demersal fishery and discard. Kattegat. Selectivity in Norway lobster trawl to reduce discard of cod, plaice etc.
Type of reference (Journal paper/report/working paper/project etc.)	Kronbak L. G. and N. Vestergaard. 2013. Environmental cost-effectiveness analysis in intertemporal natural resource policy: Evaluation of selective fishing gear. *Journal of Environmental Management* 131: 270-279. Danish Institute of Aquatic Research, Department of Sea fishery (2003). Interim report on the magnitude of and reasons for discard in the Danish fishery. The report comprises the first part of the total reporting from the project 'Analysis of bycatch and discard in the Danish fishery'. The project was conducted in cooperation between the Danish Fishermen organization and the Danish Institute of Aquatic Research Michael Andersen, DF, Jørgen Dalskov, DFU, Henrik Degel, DFU, Carsten Krog, DF. Januar 2003. Nielsen, J. Rasmus, Svend Erik Andersen, Jan-Tjeerd Boom, Søren Eliasen, Hans Frost, Ayoe Hoff, Ole Jørgensen, Carsten Krog, Lone Grønbæk Kronbak, Christoph Mathiesen, Sten Sverdrup-Jensen og Niels Vestergaard (2007) IMPSEL projektet: Implementering af mere selektive og skånsomme fiskerier. Konklusioner, anbefalinger og perspektivering (The IMPSEL project: Implementing more selective and sustainable fisheries). DFU rapport 177-07. DTU-Aqua (Danish Institute of Aquatic Research), København. Kronbak, Lone Grønbæk, Svend Erik Andersen, Jan-Tjeerd Boom, Søren Eliasen, Hans Frost, Ayoe Hoff, Ole Jørgensen, Carsten Krog, Christoph Mathiesen, Rasmus Nielsen, Sten Sverdrup-Jensen og Niels Vestergaard (2007) IMPSEL projektet: Implementering af mere selektive og skånsomme fiskerier. konsekvenser for ressource, fiskere og samfund ved implementering af selektive og skånsomme fiskerier (The IMPSEL project: Implementing more selective and sustainable fisheries. Consequences for resources, fishermen and the society of implementing more selective and sustainable fisheries).

	IME rapport 11/07, Syddansk Universitet. Eliasen, Søren, Christoph Mathiesen, Svend Erik Andersen, Jan-Tjeerd Boom, Hans Frost, Ayoe Hoff, Holger Hovgård, Ole Jørgensen, Carsten Krog, J. Rasmus Nielsen, Espen Nordberg og Niels Vestergård (2007) IMPSEL-projektet: Implementering af mere selektive og skånsomme fiskerier. Begreber og internationale erfaringer (The IMPSEL project: Implementing more selective and sustainable fisheries. Concepts and international experience). IFRO rapport nr. 195. Fødevareøkonomisk institut, København.
Please give a short description of the work described in the reference (1-2 pages). E.g. what species and fleets are described in the study, how is the study performed (model evaluations, interviews, others), what are the conclusions of the work?	The project used a linear programming model for the Danish North Sea demersal fishery to assess options of reduced discard by a reallocation of individual quotas. For the Kattegat the impact of mesh size changes was assessed by use of a bioeconomic model with an age structured fish stock component as used by the TEMAS model developed by DTU-Aqua.

Name of reference	Bi-mortality in Fisheries (1994-2003)
Case study that the reference covers	A range of activities were organized by the Nordic Working Group for Fisheries under the Nordic Council of Ministers (NCM)
Type of reference (Journal paper/report/working paper/project etc.)	Christensen S. 1996. Potential Bio-economic Impact of Reduced Mortality of Cod End Escapees in the Shrimp Fishery in the Davis Strait in Soldal. A. V. edt.: *Bidødelighed innordiske trawlfiskerier. Volum 2: Konsekvensudredninger*. Nord 1996:17. Nordic Council of Ministers. Copenhagen. Frost H. 1996. Economic Impact of Changes in By-Mortality in Soldal. A. V. edt.: *Bidødelighed in nordiske trawlfiskerier. Volum 2: Konsekvensudredninger*. Nord 1996:17. Nordic Council of Ministers. Copenhagen. Nordic Council of Ministers (2003) Report from a Workshop on discarding in Nordic fisheries, Editor: John Willy Valdemarsen, Fangstseksjonen, Havforskningsinstituttet, Bergen. Sophienberg Slot, København, 18 – 20 november 2002. TemaNord 2003:537. Nordic Council of Ministers, Copenhagen.
Please give a short description of the work described in the reference (1-2 pages). E.g. what species and fleets are described in the study, how is the study performed (model evaluations, interviews, others), what are the conclusions of the work?	The project investigated the mortality rates of escaped fish that were caught by trawl in the Baltic Sea (later further investigated in the BACOMA project). These mortality rates were used in a bioeconomic model (BIF) with and age structured fish stock component to assess the economic repercussions on the fishing fleets.

3. Knowledge gaps

For the case study you are involved in, please consider possible knowledge gaps that may at present (i.e. at the beginning of the Discardless project) distort/bias our perception of possible reactions to the landing obligation (LO). E.g. imperfect knowledge of incentives and motivation to discard, missing economic data that will hinder our evaluations of the effects of the LO. Please list these knowledge gaps, and – if possible – discuss how you think we, through the Discardless project, can mitigate these gaps (e.g. through quantitative and qualitative data collection).

Some information about costs of handling fish that would have been discarded previously and the prices the landings can fetch. National work has been carried out in this field but more information will be collected during the project period, see Larsen *et al* (2013) under item 1. A working group is set up under the Danish Ministry aiming at providing information with respect to the LO. Representatives for the industry, the fishermen's associations, the ministry and the research institutes are members of the group.

SEAFISH (Lewis Cowie)

1. **Models/data:**

Fill out the following for each of the (bio) economic models you have knowledge of that 1) has already been used to evaluate economic effects, not necessarily discarding issues, concerning your case or 2) have been used or can be used for assessment of your case or other similar fisheries with respect to discard:

Model name (if any)	Seafish Landing Obligation EIA Bioeconomic Model (LOEB) based on FishRent
Case study or fishery that the model will/already covers	North Sea and West of Scotland
Give a short description of the model (economic components, biological components, multi/single fleet/species, etc.)	• Analyses the potential impact on UK fleet activity and performance had the landing obligation been applied in 2013; the model is calibrated with 2012-13 data, the last year for which full economic and logbook data is available. • Estimates the effect on the fleet after the implementation of the landing obligation in 2016 and in 2019: results include landings, effort, net profit, revenue and number of vessels in the fleet required to maintain the 2013 levels of fishing effort. • Deals with different scenarios to assess the relative difference between methods of interpreting and implementing the landing obligation (quota uplift, extent of exemptions (de-minimus, high survivability), interspecies flexibility) and under a combination of scenarios. • Gives an estimate of the volume and value of fish left in the sea each year under different scenarios. • Results are at a producer's organisation level (e.g – N. Sea whitefish trawl, west of Scotland Nephrops trawl) rather than at an individual vessel level. • The model deals with multiple fleet segments which are defined by nation, main area, main gear, FPO, target species and vessel length group. • Species are included by area as follows: - North Sea (Nephrops, sole, plaice, hake, cod, haddock, whiting, saithe, northern prawn) - NW waters (Nephrops, sole, plaice, hake, cod, haddock, whiting, saithe) - SW waters (Nephrops, sole, plaice, hake) - Other waters (species subject to catch limits) • The model can handle constant or elastic prices and inter-species flexibility (9% inter species swaps)
Which data is used/needed as input to the model (economic – e.g. STECF, biological e.g. ICES, other)	Data required for the key fleets and stocks modelled includes: • Economic data by fleet segment – number of vessels, average d.a.s, fuel price, fishing revenue, variable costs, fixed costs, crew, fuel, capacity costs (Seafish data) • Management data by stock and fleet segment – TAC share, vessel catch composition (ICES, STECF, MMO) • Biological data by stock – biomass, recruitment parameters, fishing and natural mortalities • Production data for undersized/over-quota catch, fish prices
Do you have preferences for use certain models in Discardless (task 2.3+2.4)?	

2. Existing knowledge

For the models listed under item 1 plus other (bio) economic analyses with relevance to your case study please list reports/working papers/journal articles/other literature/ongoing projects etc., that maps/investigates effects of discards or landings obligation in your area/CS. For each listed reference, please fill out the following:

<table>
<tr><td>Name of reference</td><td>Landing obligation economic impact assessment, Seafish</td></tr>
<tr><td>Case study that the reference covers</td><td>North Sea and West of Scotland</td></tr>
<tr><td>Type of reference (Journal paper/report/working paper/project etc.)</td><td>Working paper/project – Landing obligation economic impact assessment; Phase 2, Seafish
Jennifer Russell, Hazel Curtis, Rod Cappell, Sebastien Metz, and Simon Mardle.</td></tr>
<tr><td>Please give a short description of the work described in the reference (1-2 pages). E.g. what species and fleets are described in the study, how is the study performed (model evaluations, interviews, others), what are the conclusions of the work?</td><td>The Seafish LOEIA is an ongoing project consisting of three parts; the choke analysis), the bioeconomic model, and qualitative research into the onshore impacts of the LO.

Choke analysis - identifies, based on 2013 activity, when the initial quota allocation of a particular stock could have “choked” the fleet.

Of most interest to the DiscardLess project is the bioeconomic modelling phase which uses a model based on Fishrent to investigate the impacts of the LO under different conditions and compare options (rather than offering specific forecasts).

The bioeconomic model addresses:
• Economic performance of the modelled fleets
• Evaluation of fleets at the segment level across the UK
• Analysis of catching sector only
• Opportunities available for modelled fleets, including technology/gear change response
• Estimated biological status of modelled stocks (including an estimate of volume and value of fish left in the ocean after each year)
• Impact of the landing obligation on demersal fleets in 2016/19
• Impact on fleets of quota flexibility, quota uplift and some exemptions

The model does not address:
• Spatial analysis at a detailed level (for example not lower than “North Sea”)
• Analysis of fleets that are not defined as “demersal fleets”
• Detailed stock assessment
• Onshore impacts

Outputs include:
• Revenues
• Biomass
• Fuel costs
• Crew costs
• Gross cash flow
• Profit
• Break-even revenues
• GVA</td></tr>
</table>

	• Variable costs • Fixed costs • Capital costs • Net present value of a fishery • GVA by fleet • Estimated number of fishermen • Ratio of break-even revenue to baseline revenue	• Estimated fishing mortality • Estimated catch of stock by fleet • Ratio of estimated discards/catch • Effort in days of a fleet • Ratio of break-even effort to baseline effort
	The model is developed as a means for undertaking the EIA and not for general use; however a limited model (dealing only with relevant fleets and relevant stocks) will remain in the public domain in the form of an MS Excel workbook. This model will operate at a relatively high fleet level and therefore will not require confidential economic data to be input directly.	

3. Knowledge gaps

For the case study you are involved in, please consider possible knowledge gaps, that may at present (i.e. at the beginning of the Discardless project) distort/bias our perception of possible reactions to the landing obligation (LO). E.g. imperfect knowledge of incentives and motivation to discard, missing economic data that will hinder our evaluations of the effects of the LO. Please list these knowledge gaps, and – if possible – discuss how you think we, through the Discardless project, can mitigate these gaps (e.g. through quantitative and qualitative data collection):

Model name	
Anticipated gap model	
Anticipated gap data	Size classes of fish currently caught (both discarded and landed) and the price each size class recieves at market. As the LO is implemented the size distribution of fish landed is likely to change significantly which may have an impact on economic performance as different sized fish are more valuable than others. The direct cost to the catching industry (if any) of handling and disposing of fish below the MCRS.
Other anticipated knowledge gap	Clarification on the legislation: exactly how exemptions will be applied (e.g inter-species flexibility, high survivability, de-minimus), zero TAC species, quota uplift and allocations.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 633680

SEAFISH (Lewis Cowie)

Review of empirical work that can support Discardless research.

See Appendix 1.

DTU Aqua (Clara Ulrich)

1. **Models/data:**

Fill out the following for each of the (bio) economic models you have knowledge of that 1) has already been used to evaluate economic effects, not necessarily discarding issues, concerning your case or 2) have been used or can be used for assessment of your case or other similar fisheries with respect to discard:

Model name (if any)	Fcube
Case study or fishery that the model will/already covers	North Sea demersal / Celtic Sea / West of Scotland / Iberian Waters / Eastern Mediterranean
Give a short description of the model (economic components, biological components, multi/single fleet/species, etc.)	Fleet and metier based forecast, tailored to providing mixed-fisheries considerations to the annual ICES single-stock TAC advice. Can also be translated into effort quota, as effort is one input. Suitable for catch quotas and discards ban scenarios. Can be used to help designing flexible Harvest Control Rules to avoid conflicting single-stock management objectives. Fcube estimates catch potentials for distinct fleets and metiers based on traditional catch and effort information, thus estimating the potentials for single species TAC under- or over-shoots. Initially biological deterministic short-term forecast, reproducing and building on ICES single-stock advice. Modularly extended towards stochastic medium-term simulations (single-species MSE linked with Fcube as implementation error through over/under quota catches) and economic impact assessment. Flexibility to add any user-defined parameter uncertainty in the script (e.g. catchability) The model is now annual and non-spatial. Unlimited number of fleets, metiers and stocks. All implemented in R/FLR scripts and functions
Which data is used/needed as input to the model (economic – e.g. STECF, biological e.g. ICES, other)	Standard international datasets: Single stock assessment and advice, but can be also adapted to stocks without analytical assessment. Fleet and metier catch and effort data as available from e.g. ICES InterCatch, STECF databases or directly from national institutes. DCF Economic data
Do you have preferences for use certain models in Discardless (task 2.3+2.4)?	The recent experience has shown that this approach could deliver many results without major additional work. By its linking with fleets and metiers and age-based assessment, it is well suited for discards analyses.

2. **Existing knowledge**

For the models listed under item 1 plus other (bio) economic analyses with relevance to your case study please list reports/working papers/journal articles/other literature/ongoing projects etc., that maps/investigates effects of discards or landings obligation in your area/CS. For each listed reference, please fill out the following:

Name of reference	Fcube
Case study that the references cover	North Sea demersal

Type of reference (Journal paper/report/working paper/project etc.)	**<u>Articles:</u>** Hoff, A., Frost, H., Ulrich, C., Damalas, D., Maravelias, C. D., Goti, L., and Santurtún, M. 2010. Economic effort management in multispecies fisheries: the FcubEcon model. – ICES Journal of Marine Science, 67: 1802–1810 Kraak, S.B.M.; Bailey, N.; Cardinale, M.; Darby, C.; Oliveira, J.A.A.; Eero, Margit; Graham, N.; Holmes, S.; Jakobsen, T.; Kempf, A.; Kirkegaard, Eskild; Powell, J.; Scott, R.D.; Simmonds, E.J.; Ulrich, Clara; Vanhee, W.; Vinther, Morten. Lessons for fisheries management from the EU cod recovery plan. In: Marine Policy, Vol. 37, 2013, p. 200-213. Ulrich, C., Reeves, S.A., Vermard, Y., Holmes, S., and Vanhee W., 2011. Reconciling single-species TACs in the North Sea demersal fisheries using the Fcube mixed-fisheries advice framework. ICES Journal of Marine Science, 68: 1535–1547 **<u>ICES Mixed fisheries advice:</u>** http://www.ices.dk/sites/pub/Publication%20Reports/Advice/2015/2015/mix-nsea.pdf **<u>ICES reports:</u>** ICES 2006. Report of the Working Group on Workshop on Simple Mixed Fisheries Management Models. ICES CM 2006/ACFM:14 Annual reports of ICES WGMIXFISH. Most recent ones are: ICES. 2015. Report of the Working Group on Mixed Fisheries Advice for the North Sea (WGMIXFISH-NS), 26-30 May 2014, ICES HQ, Copenhagen, Denmark. ICES CM 2014/ACOM:22. 95 pp. and ICES. 2015. Report of the Working Group on Mixed Fisheries Methods (WGMIXFISH-METH), 20-24 October 2014, Nobel House, London, United Kingdom. **<u>STECF and JRC reports:</u>** Jardim, E.; Urtizberea, A.; Motova, A.; Osio, C.; Ulrich, C.; Millar, C.; Mosqueira, I.; Poos, JJ.; Virtanen, J.; Hamon, K.; 2013. Bioeconomic Modelling Applied to Fisheries with R/FLR/FLBEIA. JRC79217. DOI: 10.2788/84780 Scientific, Technical and Economic Committee for Fisheries (STECF) – Evaluation of management plans: Evaluation of the multi-annual plan for the North Sea demersal stocks (STECF-15-02). 2015. Publications Office of the European Union, Luxembourg, 152 pp.

Additional models known:

Name of reference	FishRent (A. Hoff)
Case study that the reference	North Sea demersal

covers	
Type of reference (Journal paper/report/working paper/project etc.)	See above and also see work in MYFISH project

Name of reference	FishRent (S. Simons)
Case study that the reference covers	Saithe fishery + other gadoids
Type of reference (Journal paper/report/working paper/project etc.)	See work in MYFISH /STECF 15-05

Name of reference	SIMFish (K. Hamon)
Case study that the reference covers	Southern North Sea
Type of reference (Journal paper/report/working paper/project etc.)	See work in MYFISH /STECF 15-05

Name of reference	IBM Displace model (F. Bastardie)
Case study that the reference covers	Danish fishers, mainly Baltic Sea
Type of reference (Journal paper/report/working paper/project etc.)	Bastardie, F, Nielsen, JR & Miethe, T 2014, 'DISPLACE: a dynamic, individual-based model for spatial fishing planning and effort displacement - integrating underlying fish population models' Canadian Journal of Fisheries and Aquatic Sciences, vol 71, no. 3, pp. 366-386., 10.1139/cjfas-2013-0126 SOCIOEC-BENTHIS projects

3. Knowledge gaps

For the case study you are involved in, please consider possible knowledge gaps that may at present (i.e. at the beginning of the Discardless project) distort/bias our perception of possible reactions to the landing obligation (LO). E.g. imperfect knowledge of incentives and motivation to discard, missing economic data that will hinder our evaluations of the effects of the LO. Please list these knowledge gaps, and – if possible – discuss how you think we, through the Discardless project, can mitigate these gaps (e.g. through quantitative and qualitative data collection):

Model name	
Anticipated gap model	No accurate predictive model of fishers behaviour
Anticipated gap data	Costs by metier not available; linkages between economic database and biological database are quite poor; the future of the STECF "effort database" is uncertain
Other anticipated knowledge gap	Discards data will become less available and less reliable after the LO

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Marine Scotland Science (Coby Needle)

Name of reference	Honeycomb (Coby Needle)
Case study that the reference covers	North Sea and West of Scotland
Type of reference (Journal paper/report/working paper/project etc.)	Needle, C. L. Honeycomb: a spatio-temporal simulation model to evaluate management strategies and assessment methods. – ICES Journal of Marine Science, doi: 10.1093/icesjms/fsu130.

6.2 Celtic Sea (MI, Graham)

MI has been coordinating a Commission funded LOT project to develop a decision support tool for the development of mixed-fisheries plans for the Celtic Sea (project DAMARA)
The core model is FLBEIA developed by AZTI and the focus has been on making a user friendly tool for stakeholders (managers/industry) that allows them to assess the biological and economic consequences of different management interventions ("scenarios") e.g. increases in selectivity, effort control etc. This is based on R Shiny tools for this purpose.
At the last stakeholder meeting there was a strong desire that the model should be able to consider the implications of the landings obligation – choke scenarios associated with different phasing-in options; possible implications of different de minimis and high survival exemptions.
There are a number of obvious data limitations not least the lack of economic data at a métier level and also how fleets are defined from an operational perspective.

6.3 Eastern Channel (IFREMER, Lehuta and Vermard)

1. Models/data:

Fill out the following for each of the (bio) economic models you have knowledge of that 1) has already been used to evaluate economic effects, not necessarily discarding issues, concerning your case or 2) have been used or can be used for assessment of your case or other similar fisheries with respect to discard:

Model name (if any)	ISIS-Fish
Case study or fishery that the model will/already covers	French demersal mixed fishery of the Eastern English Channel, ICES division VIId. Stocks considered: Sole, Plaice, Red Mullet, Scallops (2 populations), Cuttlefish, Squids (2 populations). Cod and whiting may be added in course of the project. Fleet considered: French netters, bottom trawlers, dredgers. Other French fleets and fleets from other countries are accounted for by applying and adjusting an extra fishing mortality factor.
Give a short description of the model (economic components, biological components, multi/single fleet/species, etc.)	ISIS-Fish is a deterministic fisheries dynamic simulation model designed to investigate the consequences of alternative policies on the dynamics of resources and fleets for fisheries with mixed-species harvests (Mahévas and Pelletier 2004; Pelletier et al, 2009). Fishing mortality is the result of the interaction between the spatial distribution of population abundance resulting from the population submodel and the spatial distribution of fishing effort provided by the exploitation and management submodels at a monthly time-step. Fishing effort is standardized per métier and fleet according to gear selectivity and efficiency, ability to specifically target a species and technical efficiency. The Eastern Channel application focuses on the French fleets operating in ICES area VIId and on the most valuable species landed by French fleets: sole (*Solea solea*) and scallops (*Pectens maximus*). The majority of sole landings comes from netters and, to a more limited extends, bottom trawlers and mixed trawlers. Scallops are mainly landed by dredgers. The model therefore focuses on these four fleets, consisting of a total of 448 boats in average over 2008-2010. The fleet segmentation used is the segmentation created by the French Fishery Information System (SIH), which groups French vessels based on the main, or two main, gears used during the year. We further segmented these SIH-fleets according to length class of the vessel and home region. The other boats operating in the EEC (including international fleets) are pooled into an inexplicit fleet "OTHER" which impact stocks through a fishing mortality adjusted to management constraints. The rest of the value landed by the selected fleets mainly consists in cephalopods, sea bass, whiting, red mullet, cod and plaice. The model currently describes the dynamics of scallops (2 populations), sole, plaice, red mullet and cephalopods (2 populations of squids, a population of cuttlefish). It accounts for population spatial distribution and migrations in course of the year.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 633680

Population zones in the ISIS-Fish model of the Eastern Channel are based on the habitat structure identified for the Atlantis application in this area. Regarding métier zones, logbooks helped identifying the main ices rectangles of practice for each gear and fleet. Fleet behavior is modeled through the dynamical modification of effort allocation on métiers in course of the simulation. A gravity model accounts for the mix of tradition and opportunist behavior of fishers when they choose which métier to practice. Opportunism was approximated by a function proportional to landed value minus fuel costs per unit of effort and inversely proportional to landed quantity. Fuel costs are inferred based on distance between harbor and fishing grounds while prices are computed dynamically as a function of landings and seasonality.

More details about the EEC application can be found in Lehuta et al. (2015).

<u>Discards, TAC and landing obligation</u>

In the model, in the **status quo** simulations, discards occur if:

1- **Quota** for a species is reached: Catches cumulate monthly in course of the year until the TAC of a species is reached. Thereafter the métier can still be practiced but the species which TAC is exhausted is discarded. The gravity model is supposed to make fishermen move away from the species in consequence.
2- Fish under **minimum landing size** (equivalent to a minimum age (in month) given model determinist hypotheses on growth) is caught. For now, the model assumes a strict size threshold for discard. Data analyses are expected to allow challenging the current hypothesis with a distribution of discards across sizes to reflect both the diversity of reasons for discarding and the heterogeneity of size at age.

A survival rate for discarded fish can be applied, when available (the model assumes 0 for all species but scallops for which the survival rate is 1).

Under **landing obligation** the assumptions are changed:

1- When **TAC** is reached, the attractivity of all métiers catching the species is set to zero. Exemptions can take place here, but the price of the exhausted species is set to zero to reflect the absence of commercialization opportunities.
2- If fish under **minimum conservation size** are caught they are landed but their price is set to zero. According to the gravity model chosen the attractivity of the métier should be reduced due to these extra non-commercial landings.

Space discretization: 0.5 x 0.5 cells

	Time step: month Publications: Lehuta et al. 2015, Pelletier et al. 2009
Which data is used/needed as input to the model (economic – e.g. STECF, biological e.g. ICES, other)	The biological models build on the structure and parameters of the ICES assessment models when available and on scientific survey data and literature otherwise. The parameters of effort standardization are computed from statistical analysis of log-book data. Price equations are derived from sale slips analysis.
Do you have preferences for use certain models in Discardless (task 2.3+2.4)?	ISIS-Fish will be developed and parameterized for the Eastern Channel in the WP1, however, given its fleet dynamics component (and some economics: dynamic prices, computation of fuel costs and revenues), it might also answer some questions addressed by task 2.3 & 2.4.

2. Existing knowledge

For the models listed under item 1 plus other (bio) economic analyses with relevance to your case study please list reports/working papers/journal articles/other literature/ongoing projects etc., that maps/investigates effects of discards or landings obligation in your area/CS. For each listed reference, please fill out the following:

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Name of reference	SOCIOEC Project
Case study that the reference covers	Eastern English Channel
Type of reference (Journal paper/report/working paper/project etc.)	EU project
Please give a short description of the work described in the reference (1-2 pages). E.g. what species and fleets are described in the study, how is the study performed (model evaluations, interviews, others), what are the conclusions of the work?	The work used the ISIS-Fish model described above. It focused on sole and on the comparison of various harvest control rules rather than on the landing obligation. Assumptions were made regarding exemptions of landing obligation for certain métiers. The status quo scenario mimics the management plan soon to be enforced for sole, which follows the transition to MSY scenario advised by ICES. Current minimum landing size for sole and plaice, as well as TACs for plaice (2010 value) and for red mullet (2010 advice) are simulated. Alternative management plans are evaluated for sole building on harvest control rules based on mean length rather than fishing mortality. The impact of landing obligation is also simulated (including de minimis). Management objectives focus on sole with its common by-catch species plaice. FMSY and Biomass limit reference points are available for both species. The impacts on the other species are evaluated by mean of the growth rate of the population over the simulated years or by the catch over the last year of simulation for cephalopods. Since mean length of sole is the indicator used in alternative HCRs, it is monitored in simulations and expected to increase. The amount of discards is recorded to evaluate the achievement of discard reduction. Economic objectives could not be derived from interviews with stakeholders but the ratio of gross revenues over fuel costs of travel is monitored during simulations as a

	proxy for fleet viability. The management plan decided for sole, based on a transition to MSY in 5 years, allows objectives to be reached only if the landing obligation is implemented. Nevertheless, it is the most effective of the 5 harvest control rules tested for sole (which include the DLS rule based on the indicator of mean length in the stock). Management for sole also benefits plaice that is caught simultaneously but the effects on red mullet vary according to the level of opportunism hypothesized for fishermen. As for discard reduction, the *de minimis* system would need to be clarified before results can be properly assessed. In terms of economic performance, effectiveness of measures mostly depends on the fleet considered and their dependency on sole. However the simulations evidenced a good coherence between biological and economic objectives in the long term, and this particularly for the management strategies that were the most constraining in the short term, such as the landing obligation. The external factors only marginally change the results. Overall, the more opportunist the fleets, the less performing the management both in term of biological and long-term economic objectives. (copied f*rom SOCIOEC D5.6, see http://www.socioec.eu/images/SOCIOEC%20D5%206%20Rating%20ex%20ranking%20management%20measures%20on%20%20%20%20%20CS%20level3.pdf for full details and results*)

Name of reference	SelectFish
Case study that the reference covers	Eastern English Channel
Type of reference (Journal paper/report/working paper/project etc.)	National project (France)
Please give a short description of the work described in the reference (1-2 pages). E.g. what species and fleets are described in the study, how is the study performed (model evaluations, interviews, others), what are the conclusions of the work?	The SELECFISH project aimed at testing and developing selective devices for the French artisanal trawler fleets operating in the Eastern Channel and North Sea. The pursued goal was to allow a reduction of discards particularly for species under TAC and being impacted by the landing obligation. Impacts of tested devices were thus evaluated on whiting, plaice, horse mackerel, herring (species subjected to the landing obligation and abundantly discarded by this fishery) and squid, cuttlefish, red mullet, mackerel and cod (commercial species of importance for these fisheries). The project allowed a test of square mesh cylinders (SMC) of various sizes (80, 100 and 115mm gauge) and various lengths (1 and 2m). The association of SMC in 80mm of 2m length with selective grids was also tested. Each device was trialed at sea for at least 5 days on board professional fishing vessels. The method used to carry out the tests consisted in parallel hauls: two trawlers fished side by side, one equipped with the selective device, the other with traditional gear and onboard observers sampled the catches on both vessels. The reductions in discards allowed by tested devices ranged from 20 to 78% depending on the device considered. Their use however caused immediate commercial losses which ranged between 0 and 35% of the sales. SMC have interesting effects on whiting: they allow a large reduction of discarded quantities (from 35 to 60%) while maintaining or even increasing the marketable catches. These SMC are also very effective for small pelagic species escapement (horse

	mackerel, herring, mackerel). However, they are rather inefficient on flat fishes (except for the biggest mesh sizes) because le level of escapement for marketable fish is as high as for discarded fish. The association of SMC in 80mm of 2m length with selective grids were not significant but do not seem much more interesting than the SMC on its own. With SELECMER semi rigid grids of 23mm spaced vertical bars, the results on whiting are similar as with the SMC alone. With SAUPLIMOR rigid grid, discards are reduced by almost 80%. Associated commercial losses are nevertheless very important (in particular, a twofold decrease in cuttlefish and squid catches). These tests highlight once again the complexity of selectivity improvement for mixed fisheries. Some of the tested devices revealed appropriate when a specific species is targeted, but none of them is suitable for a year-round activity.

3. Knowledge gaps

For the case study you are involved in, please consider possible knowledge gaps, that may at present (i.e. at the beginning of the Discardless project) distort/bias our perception of possible reactions to the landing obligation (LO). E.g. imperfect knowledge of incentives and motivation to discard, missing economic data that will hinder our evaluations of the effects of the LO. Please list these knowledge gaps, and – if possible – discuss how you think we, through the Discardless project, can mitigate these gaps (e.g. through quantitative and qualitative data collection)

Model name	ISIS-Fish
Anticipated gab model	-International fleets not explicitly modeled - Model limited to exploited population - Simplist behavior model (possibly replaced by decision rules elaborated with fishermen) - Limitations in modelling of fish distribution and their inter-annual variations may biais the predicted efficiency of avoidance scenarios
Anticipated gab data	Limited access to economic and discard data(depending on species)
Other anticipated knowledge gab	-Limited understanding of current discarding behavior may biais the status quo evaluation -Limitations in modelling of fish distribution and their inter-annual variations may biais the predicted efficiency of avoidance scenarios

References

Sigrid Lehuta, Youen Vermard and Paul Marchal (2015) A spatial model of the mixed demersal fisheries in the Eastern Channel, in *Marine Productivity: Perturbations and Resilience of Socio-ecosystem, Proc. 15th French-Japan. Oceanogr. Symposium,* H.-J. Ceccaldi et al. (eds.): p187-195.

Pelletier Dominique, Mahevas Stephanie, Drouineau Hilaire, Vermard Youen, Thebaud Olivier, Guyader Olivier, Poussin Benjamin (2009). Evaluation of the bioeconomic sustainability of multi-species multi-fleet fisheries under a wide range of policy options using ISIS-Fish. Ecological Modelling, 220(7), 1013-1033. Publisher's official version: http://dx.doi.org/10.1016/j.ecolmodel.2009.01.007 , Open Access version : http://archimer.ifremer.fr/doc/00000/6782/

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6.4 Bay of Biscay (Azti, Prellezo)

Review of empirical work that can support Discardless research. See appendix 2 for a case study description.

6.5 Western Mediterranean (IEO, Quetglas)

1. Models/data:

Fill out the following for each of the (bio) economic models you have knowledge of that 1) has already been used to evaluate economic effects, not necessarily discarding issues, concerning your case or 2) have been used or can be used for assessment of your case or other similar fisheries with respect to discard:

Model name (if any)	MEFISTO (Mediterranean Fisheries Simulation Tools, www.mefisto.info)
Case study or fishery that the model will/already covers	Mediterranean Sea
Give a short description of the model (economic components, biological components, multi/single fleet/species, etc.)	The MEFISTO bioeconomic simulation model, tailored to Mediterranean fisheries specificities, allows simulating the management of Mediterranean fisheries through effort control and technical measures (selectivity). MEFISTO includes the possibility of testing the effects of removing vessels from the fishery or reducing their fishing time, as well as changing the selectivity patterns by age class. The model has been built in a modular way on a system of "boxes". A total of three boxes are defined: *1. The stock box*. This simulates the dynamics of a particular stock. The input is the fishing effort and the catchability (these coming from *the fisherman's box*) whose product constitutes the fishing mortality applied to the stock. The output is the catch that goes into *the market box*. *2. The market box*. This converts the catch into money by way of a price function. The Price function includes the base price, the average fish size, and the fish offer. Additionally, sudden variations in price for exogenous reasons are also possible. *3. The fisherman box*. This simulates the fisherman's economic behaviour. Its input is the money coming from the market box; its output is the effort (upper-limited by law or not) and the catchability, over which the fisherman has certain control by way of function of his capital. Since the model is multi-species and multifleet, it may contain several stock, market and fisherman boxes.
Which data is used/needed as input to the model (economic – e.g. STECF, biological e.g. ICES, other)	Economic: STECF but also specific from the vessel owner. Biological: VPA outputs from GFCM assessments.
Do you have preferences for use certain models in Discardless (task 2.3+2.4)?	Partner 3-IEO does not participate in task 2.3 and 2.4, but MEFISTO will be used in task 2.5.

2. Existing knowledge

For the models listed under item 1 plus other (bio) economic analyses with relevance to your case study please list reports/working papers/journal articles/other literature/ongoing projects etc., that *maps/investigates effects of discards or landings obligation in your area/CS. For each listed reference, please fill out the following:*

Name of reference	*The Obligation to land all catches: consequences for the Mediterranean (http://www.europarl.europa.eu/RegData/etudes/note/join/2014/529055/IPOL-PECH_NT%282014%29529055_EN.pdf).*
Case study that the reference covers	Mediterranean
Type of reference (Journal paper/report/working paper/project etc.)	Report
Please give a short description of the work described in the reference (1-2 pages). E.g. what species and fleets are described in the study, how is the study performed (model evaluations, interviews, others), what are the conclusions of the work?	This document was requested by the European Parliament's on Committee on Fisheries and was elaborated by the IEO (Bellido et al., 2014). The report provides a state-of-the-art of fishery discards in the Mediterranean, discussing consequences of the discards ban and providing some recommendations on how to tackle the problem of juvenile catches. The aim of the report is to provide a comprehensive qualitative analysis of the discards in the EU Mediterranean fisheries as well as to assess effects of the discard ban in the Mediterranean, with a particular focus on the discards on juveniles. The approach is focused on five main aspects, comprising a global view for the successful implementation of the new CFP, particularly in the aspects related to the discard ban and landing obligation: • European Mediterranean fisheries. • Discards in EU Mediterranean fisheries. • Discards mitigation measures. • Use of un-wanted catches, commercialization and black market. • Obligation to land all catches – implementation of the new CFP. The methodology used comprised a twofold methodological approach: • provision of a general overview about the Mediterranean fisheries and discards, based on the collection of recent information from academic publications, studies and reports of European Institutions, authorities of the Members States, and any other relevant sources; • analysis of primary data collected from fieldwork and case studies. In some cases the IEO fishery database was used to provide useful Spanish examples to be extrapolated for different European fisheries. KEY FINDINGS • The landing obligation will provide solutions to some persistent problems derived from fishing, and will create new problems when implemented. • It will produce a better utilization of the fishing harvest, providing raw material that can be valuable to different

	valorisation industries. Inversely, it will increase removal of marine biomass and energy. • Another issue to consider is that landing such volumes of marine debris can generate important environmental pollution in land. This is a particularly sensitive issue on the Mediterranean coast, with many touristic areas and where weather is warm almost all year. If the volumes of marine debris are not disposed of by quick removal in appropriate conditions they can cause por hygienic and sanitary conditions, adversely affecting the welfare of local communities. • Apparently, there are no incentives to land unwanted catches, and penalties for failure to meet this requirement are not still clear in the Mediterranean, unlike Atlantic where penalty quotas will be implemented. • One possible consequence of the new Regulation may be the increase in ilegal marketing of fish below the minimum size. Landing, storage and transportation of juveniles will be legal and this can simplify commercialization in the black market RECOMENDATIONS 1. The best discards mitigation measure occurs at sea and it is not to catch unwanted catch. The key aspect of the Regulation should be better fishing practices to avoid unwanted catch. 2. Landing obligations for discards do not necessary reduce unwanted catch in the Mediterranean. Inversely, we agree it may increase the black market in juveniles. 3. Discards mitigation measures in the Mediterranean must be adjusted to the Mediterranean fishing management system, i.e. measures related to fishing effort and no quotas/landing TACs. We consider effective fishing management based on fishing effort as the best and most logical fishing management system. 4. Some of these measures can be reductions of fishing effort, better fishing selectivity and spatio-temporal fishing restrictions for vulnerable sizes and/or areas. 5. The discard ban and landing obligation should be accompanied by other measures for its successful implementation. Some of these measures are improvements of the control of fishing effort, effective enforcement and finally an agreement of the fishing sector to comply with the rules and regulations. 6. Discards should be managed in a fishery-by-fishery basis. Exemptions (*minimis*) can be an alternative for some selected fisheries, of course if based on scientific studies.

Name of reference	*MINOUW "Science, Technology, and Society Initiative to minimize Unwanted Catches in European Fisheries"; (H2020, ref. 634495); Period: 2015-2019; Coordinator: Francesc Maynou (ICM-Barcelona).*
Case study that the reference covers	Mediterranean
Type of reference (Journal paper/report/working	Project

paper/project etc.)	
Please give a short description of the work described in the reference (1-2 pages). E.g. what species and fleets are described in the study, how is the study performed (model evaluations, interviews, others), what are the conclusions of the work?	The MINOUW and the DISCARDLESS projects were funded under the same H2020 call, so the general objectives of both projects are the same. Regarding the Mediterranean, there have been contacts to avoid overlapping in the projects development. ABSTRACT The complexity of the problem of banning discards and bringing all unwanted catches to land makes it necessary to follow a multi-actor approach, whereby scientists, fisheries technologists, fish producers and NGOs work collaboratively to provide the scientific and technical basis to achieve the gradual elimination of discards in European marine fisheries. The project's overall objective is to minimise unwanted catches by incentivising the adoption of fishing technologies and practices that reduce pre-harvest mortality and post-harvest discards, while avoiding damage to sensitive marine species and habitats. The general approach is based on technical/technological and socioeconomic solutions on a case-by-case analysis of the main types of European fisheries. The project will analyze existing and potential discard-mitigating innovative technologies in workshop roundtables with participation of fishers, technologists and scientists. The technologies selected will be tested in field trials to experimentally assess their efficiency: among other, improved precatch identification with observational technologies and pre-harvest loss reduction by gear modification and switching to light impact gear. The results will be analyzed in terms of technological advances, marketability and cost-benefit analysis. Other actions included in the project are social and economic instruments to incentivise selective fishing and discourage discarding practices, such as ecolabelling, fisheries certification and promoting awareness among industry and consumers, and mathematical modelling of ecosystem effects of unwanted catches reduction. The MINOUW project has the following 7 working packages: WP 1. Ecological, socioeconomic and technical characteristics of discarding fisheries; WP 2. Technological and social solutions; WP 3. Impact assessment of minimizing unwanted catches and discarding; WP 4. Policy options for discards reduction; WP 5. Control and monitoring; WP 6. Awareness; WP 7. Project Coordination and Management. The general objective of this WP is the characterization of discarding in European fisheries in ecological, socioeconomic and technical terms. To this end desktop review and statistical analysis of data will be performed, to fulfil the following partial objectives. The objectives of WP1 related to socio-economical aspects are specified here: O1.1. Characterization of the study fisheries in terms of unwanted

	catches: undersized individuals of commercial species; non-commercial organisms such as benthic invertebrates; sensitive high-trophic level species (elasmobranchs, sea turtles, sea birds). Determination of the fate of unwanted catches (commercialization, discarding, and survival of discards) by type of organism and by case-study fishery. O1.2. Description of fishing strategies and fishers' socio-economic behaviour in relation to discarding practices, based on detailed analysis of existing data bases as well as information gathered from interviews with industry during the project.

Name of reference	DISCATCH "Pilot Project on catch and discard composition including solutions for limitation and possible elimination of unwanted by-catches in trawl net fisheries in the Mediterranean (DISCATCH)"; DG MARE European Commission (Contract Nº MARE/2012/24 Lot 2); Period: 2014-2015; Coordinator: Antonello Sala (CNR)
Case study that the reference covers	Mediterranean
Type of reference (Journal paper/report/working paper/project etc.)	*Project*
Please give a short description of the work described in the reference (1-2 pages). E.g. what species and fleets are described in the study, how is the study performed (model evaluations, interviews, others), what are the conclusions of the work?	The aim of DISCATCH will be to support the identification of viable solutions to address factors determining the catches of unwanted species and specimens in trawl fisheries with a view to reducing unwanted catches and eliminating discards. The main objectives of DISCATCH are: - to provide an overall assessment of the fishing fleet discarding behaviour and to identify the main reasons for discarding in Mediterranean continental shelf demersal and small pelagic trawl fisheries. - to identify measures, including technical ones related to fishing gear characteristics, to mitigate or eliminate bycatches of unwanted species and measures to eliminate discarding based on existing or new measures. DISCATCH will cover seven non-adjacent Mediterranean sub-regions, as identified by the FAO Statistical Divisions, within the Western, Central and Eastern Mediterranean Basin, where relevant demersal and small pelagic trawl fisheries occur. For every Mediterranean sub region covered by this proposal, project will provide: - a comprehensive review and analysis of scientific papers and technical reports covering fisheries for demersal and small pelagic fisheries in the selected area; - a description of commercial yields, discard rates, selectivity parameters in relation to different mesh sizes/shapes and/or net structures through existing simulation models; - a comprehensive analysis of the relevant data collected through the Commission Decision No 2010/93/EU adopting a multiannual

	Community programme for the collection, management and use of data in the fisheries sector. Where applicable, data shortcomings will be described in detail, and if needed, scientific surveys on board of commercial vessels to address such shortcomings will be performed; - statistically significant sea trials, both for demersal and small pelagic trawls, supplemented by predictive simulation models to test the use of different mesh sizes, shapes and net structure. In WP 4, DISCATCH project will analyse different socioeconomic aspects using the BEMTOOL simulation approach. WP 4. Quantifying and modelling catch and discard composition in trawl net fisheries Description of work In the last 15 years the approach using simulation models has been increasingly adopted to indicate and predict the effects of management and technical measures on fisheries from biological, economic and social points of view. The aim of using simulation models is to be able to explore options through a comparison of the expected performance of candidate technical measures and assessment strategies relative to the management objectives. As the impact on fish stocks becomes greater, as evidenced in the majority of EU fisheries, so does the need for robust and reliable simulation approaches with which to provide confident technical and management advice. However, there is some structural inconsistency across modelling approaches in Mediterranean and other European fisheries. This is mainly due to the prevalence of multi-species and multiple gears fisheries in the Mediterranean Sea, as well as to the different levels of data aggregation. Aiming at forecast the effect of different mesh sizes/shapes on the commercial yields and discards rates, as well as to assess the different performances of selected technical measures, we will use the BEMTOOL model (European Commission – Directorate General Maritime Affairs and Fisheries, Contract Nº MARE/2009/05 SI2.613770). BEMTOOL is a bio-economic simulation model conceived as a platform, where several tools and functions allows to simulate the effects of management measures and/or harvesting strategies, including the discard impact, in the short, medium and long-term (e.g. fishing effort limitations, mesh size restrictions, closed season). The BEMTOOL platform encompasses assessment tools (e.g. XSA, VPA, SURBA, FLR Libraries, etc.) bio-economic tools (e.g. BIRDMOD, MEFISTO, FISHRENT, AMURE IAM, BEMMFISH), simulation tools (e.g. ALADYM simulation model) (Darby and Flatman, 1994; Lleonart and Salat, 2000; Lleonart et al., 2003; Kell et al., 2007; Lembo et al., 2009; Spedicato et al., 2010). Furthermore, BEMTOOL allows optimal solutions in terms of fishing effort and/or catches, maximizing the sustainable production while avoiding discard and overfishing. Therefore, given the traditional model categorisation in simulation (answering the question "what if") and optimization

	(answering the question "what's best"), both the questions are expected to be answered by BEMTOOL. In order to better place the study in an Ecosystem Approach to Fisheries framework, additional simulations of selected technical measures will be performed using ecosystem models developed with the "Ecopath with Ecosim" approaches (Christensen and Walters, 2004). These models allow to analyze the potential effects of improving selectivity in demersal trawl fisheries developed in areas where these models have been constructed.

3. Knowledge gaps

There are a lot of studies characterizing the discards from different Mediterranean fisheries (e.g. species composition, catches), especially bottom trawl (see review from task 1.1). However, analyses of socio-economic data are very scarce (see review from task 2.1). That's why the main gaps are related to the social and economic implications of discards for the fishing sector (fishermen, retailers, managers). The imperfect knowledge of incentives and motivation to discards is also important, especially due to the opposition of fishermen to the Landing Obligation and the lack of clear guidelines to handle discards (e.g. what to do with discards once on land).

Under the Data Collection Framework, information on discards from on board sampling has been collected since 2003. This will allow analysing socio-economic aspects by means of modelling the implications of considering the volumes of discards in bio-economic models.

Social aspects will be more difficult to tackle and maybe it will require interviews with the different actors involved in the fishing sector. Limitations of this type of studies are well-known (e.g. qualitative data, time-consuming).

Regarding the bio-economic model MEFISTO, it has not specific implementations to deal with discards. However, the model can handle the discards problem at two different steps: 1) introducing discards in the VPA assessment (the stock box); and 2) introducing economic implications in the losses of fishermen (the fisherman box).

Further information is found in appendix 3

WESTERN MEDITERRANEAN CASE STUDY, (Javier González, Antoni Quetglas, IEO)

6.6 Eastern Mediterranean (NAYS, Triantaphyllidis)

1. **Models/data:**

Fill out the following for each of the (bio) economic models you have knowledge of that1) has already been used to evaluate economic effects, not necessarily discarding issues, concerning your case or 2) have been used or can be used for assessment of your case or other similar fisheries with respect to discard:

Model name (if any)	MEFISTO model
Case study or fishery that the model will/already covers	**EASTERN Mediterranean Case Study**
Give a short description of the model (economic components, biological components, multi/single fleet/species, etc.)	MEFISTO Stands for **ME**diterranean **FI**sheries **S**imulation **TO**ol: A bioeconomic model for Mediterranean fisheries. It has been developed by J. Lleonart, R. Franquesa and F. Maynou. The first objective of the model is to reproduce the bio-economic conditions in which the fisheries occur. The model is, perforce, multi-species and multi-fleet. The main management procedure is effort limitation, in terms of limits to fishing activity, but other management procedures are also available: capacity limitation, selectivity, or economic measures on productivity factors (fuel price, limits on investment, fish imports, subsidies, etc.). The model also incorporates the usual fishermen strategy of increasing efficiency, in order to increase fishing mortality, while maintaining the nominal effort. This is modelled by means of a function relating the efficiency (i.e., technological progress) with the capital invested in the fishery, and time. A second objective is to simulate alternative management strategies. The model allows operating with technical and economic management measures in the presence of different kind of events and performs stochastic simulations.
Which data is used/needed as input to the model (economic – e.g. STECF, biological e.g. ICES, other)	**Data requirements for MEFISTO (from the national Greek DCF and DCR)** Worksheet Species • Parameters of length-weight relationships • Von Bertalanffy parameters • Number of cohorts Worksheet cohorts • Numbers-at-age • Prop. mature-at-age • Natural mortality-at-age Worksheet recruitment • Type and parameters of stock-recruitment relationship Worksheet interact • F-at-age by fleet • Selectivity factor-at-age by fleet • Proportion of discard-at-age by fleet

	• Catchability-at-age by fleet <u>Worksheet fleet</u> • Number of vessels in the fleet • Price paid by the fisheries Administration for decommissioning vessels, usually in terms of €/GT • Share of the total revenues belonging to the owner, after discounting trade and fuel costs • Annual increment of catchability due to technological progress • Increment of catchability due to investment in capital • Proportion of profits invested in capital • Activity: Maximum number of hours a day by law or physically possible • Activity: Maximum number of day a year by law or physically possible • Activity: Average number of hours a day • Activity: Average number of days a year • Daily consumption of ice, in €/day • Commercial or trade cost, percentage paid to the fish market for the sale of fish • Maximum amount of money lended by the bank, as percentage of the capital • Price of the fuel, in €/l, paid by each fleet • Opportunity costs, i.e. cost of using the capital invested • Financial costs, costs of paying the debt incurred with the bank • Proportion of effort increase when profits are positive <u>Worksheet vessels</u> • Vessel name • Fleet name • Capital of the vessel • Capacity as GT (Gross Tonnage) • Debt to the bank at time 0 • Fuel consumption in l/day • Crew size of the vessel, including the owner if worker • Daily costs other than fuel and ice (e.g. net mending, food for the crew, etc.) • Costs paid at an annual scale, disregarding all daily costs. It may include: engine repair, shipyard, mooring, fishing license, etc. • Percentage of the annual costs that are fixed or compulsory to remain in the fishery: mooring, fishing license, ... • Percentage of the annual costs that are not compulsory, they are usually not met when the profits are negative: painting, repairs, etc. Correspond to depreciation of the capital • Effort (in terms of activity: days a year) of the vessel • Relative catchability of each vessel, i.e. relative fishing power, where the average vessel has RFP=1 <u>Worksheet market</u> • Fleet name

	• Stock name • Base or average price of main species (in €/kg) • Age-modifier of price, usually positive: larger fish fetch higher prices • Offer-modifier of price related to catch, usually negative: when the offer on the market is high, prices diminish • Offer-modifier of price related to imports, usually negative • Event-modifier of price (control variable) • Average price of secondary species (in €/kg)
Do you have preferences for use certain models in Discardless (task 2.3+2.4)?	Yes, MEFISTO

2. Existing knowledge

For the models listed under item 1 plus other (bio) economic analyses with relevance to your case study please list reports/working papers/journal articles/other literature/ongoing projects etc., that maps/investigates effects of discards or landings obligation in your area/CS. For each listed reference, please fill out the following:

Name of reference	For the East Med case study, potential data sources might exist in the data that the national Greek data collection framework collected during the following years: 1. DCF 2014 2. DCF 2013 3. DCR 2008 4. DCR 2006 5. DCR 2005 6. DCR 2004
Case study that the reference covers	The above reports cover Greece as a whole but will be used for the **EASTERN Mediterranean Case Study**
Type of reference (Journal paper/report/working paper/project etc.)	Reports
Please give a short description of the work described in the reference (1-2 pages). E.g. what species and fleets are described in the study, how is the study performed (model evaluations, interviews, others), what are the conclusions of the work?	There is no specific study for the area of Northern Greece where our case study will focus primarily. The case study will focus in the port of Nea Michaniona, where currently a fleet of 50 trawlers is based.

3. Knowledge gaps

For the case study you are involved in, please consider possible knowledge gaps that may at present (i.e. at the beginning of the Discardless project) distort/bias our perception of possible reactions to the landing obligation (LO). E.g. imperfect knowledge of incentives and motivation to discard, missing *economic data that will hinder our evaluations of the effects of the LO. Please list these knowledge gaps, and – if possible – discuss how you think we, through the Discardless project, can mitigate these gaps (e.g. through quantitative and qualitative data collection):*

Model name	MEFISTO
Anticipated gap model	
Anticipated gap data	
Otheranticipatedknowledge gap	For the EAST Med case study the possible knowledge gaps are the following: 1. Economic effects of discards are not available in Eastern Med. 2. There are also knowledge gaps of the following aspects: a. Working conditions for crew (safety,…) b. Impact on costs and income c. Handling or not for human consumption fish after landing d. Boat owner perception e. Crew perception f. Individual adaptation strategies g. Collective adaptation strategies The above knowledge gaps will be mitigated by designing semi structured interviews with boat owners as well as crew from trawlers around the area on Nea Michaniona which is a fishing port nearby Thessaloniki.

6.7 Iceland (Matis, Sigurðardóttir)

The case study will only partly fill in to WP2. Information for Iceland is found in appendix 4

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 633680

6.8 Barents Sea (UIT, Ashan)

The case study is about shrimp. It will only partly fill in to WP2. There is a bio-economic model used to set the allowed by-catch levels of juvenile cod, haddock, redfish, and Greenland halibut, see:

Reithe, S. and M. M. Ashan. 2004. Bioeconomic Analysis of By-Catch of Juvenile Fish in the Shrimp Fisheries – *an Evaluation of Management Procedures in the Barents Sea Environmental and Resource Economics* 28: 55–72.

7 Appendixes

7.1 Appendix 1. North Sea/West of Scotland summary (Lewis Cowie, Seafish)

SEAFISH (Lewis Cowie)

Review of empirical work that can support Discardless research.

Please, list existing reports and on-going studies you are aware of and that are of interest to Discardless work, by case-study area (give reference if report, name/lead organization if on-going study)

- Case-study area 1 : North Sea/West of Scotland
- **North Sea cod catch quota trials** August 2014 – Marine Management Organisation
- https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/342449/North_Sea_Cod_Catch_Quota_Trials_Final_Report_2013.pdf

- Case-study area 2 : North Sea/West of Scotland
- **A case study review of the potential economic implications of the proposed CFP landing obligation** December 2013 – Poseidon/Seafish
- http://www.seafish.org/media/publications/Poseidon_Landings_Obligation_Economic_Impact_JAN_2014_FINAL.pdf

- Case-study area 3 : North Sea/West of Scotland
- **Catch comparison trials of the flip flap netting grid trawl** August 2012 – Marine Scotland
- http://www.gov.scot/Resource/0039/00391333.pdf

- Case-study area 4 : South coast of England
- **Use of discards in bait** August 2014 - Seafish
- http://www.seafish.org/media/Publications/SR668_use_of_discards_in_bait.pdf

- Case-study area 5 : North Sea/West of Scotland
- **Landing obligation economic impact analysis final interim report one: choke analysis** March 2015 (*work ongoing*) – Seafish
- http://www.seafish.org/media/Publications/Seafish_LOEIA_Interim_Report_1_-_Final_260315.pdf

- Case-study area 6 : England
- **The English Discard Ban Trial** October 2014 – Cefas/Defra
  https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/361564/Discard_Ban_Trial_Report_v11.pdf

- Case-study area 7 : SW England
- **Catch quota trials for western haddock** September 2014 – Marine Management Organisation
- https://www.gov.uk/government/publications/catch-quota-trial-final-report-2013-western-haddock

- Case-study area 8 : SW England
- **Self-sampling in the inshore sector** October 2014 – Defra
- https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/361558/SESAMI_final_report_Final.pdf

7.2 Appendix 2. Bay of Biscay summary (Raúl Prellezo and Eider Andonegi, AZTI)

DISCARDLESS. Task 2.1. BoB case study

Raúl Prellezo and Eider Andonegi

AZTI

Abstract: The simulation to be performed is analysed describing which are the base data and constraints that we have for doing so.

1. Brief presentation of the CS and fisheries concerned

Bay of Biscay (Figure 1) is a highly productive system. It creates the perfect conditions to multispecies trawling fleets to make use of this productivity. In particular there is a trawl fleet based in the ports of Ondarroa (Basque Country, Spain) operating in this area targeting more than 48 different species (see Annex 1 for a complete list of landings and annex 2 for the code references in English and Spanish) and landing and selling always back in Ondarroa.

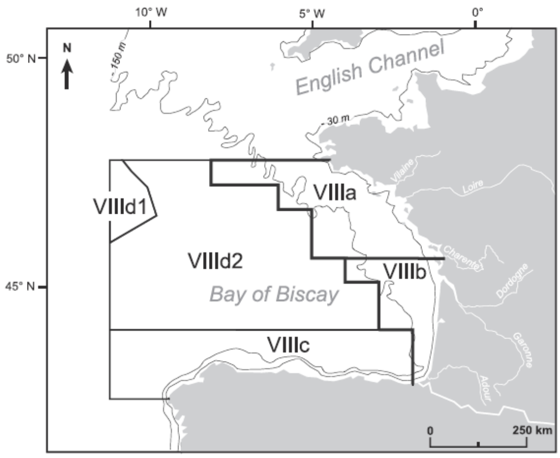


Figure 1. Case study area: Bay of Biscay

The operation of this fleet can be divided into metiers. These métiers are based on the target assemblage landed by trip, as stipulated in the Commission Decision 2008/949/EC Appendix IV footnote (b), However, this Commission decision only considered general and non-specific assemblage of species (crustaceans, cephalopods, demersal fish ...), which are not detailed enough to define the different fishing tactics followed by this fleet. Based on direct interviews with skippers, three different "group of target species" were identified; the percentage of each group within the landing is later used to allocate trips into define métiers.

A first metier, pair trawlers (PTB hereafter), use a very high vertical opening bottom trawl to target hake. The activity is constant along the year, with a slight effort reduction during summer period. Total landings reach 2293 tons in 2013, and hake landings (the main target species) 1682 tones.

A second metier, bottom otter trawlers targeting demersal species (OTD hereafter), has a constant activity along the year, with slight effort reduction during summer period. Total landings reach 2836 tons in 2013. Hake (*Merluccius merluccius*), anglerfishes (*Lophius piscatorius* and *Lophius budegassa*) and megrims (L. whiffiagonis) are the main landed species, but there are more than 65 other landed species (pouts, dogfish, triglids…).

The third metier, bottom otter trawlers targeting mixed species (OTM hereafter) concentrates its activity during winter seasons. Total landings reached 655 tons in 2013. Squids, cuttlefish, and mullets are the main target species in this métier.

PTB is mainly landing hake. Total discards are around 15 % of the total catch. Hake individuals under MLS and pelagic species (horse mackerel, and mackerel) are the main component of the discarded catch fraction. There are both market and regulation reasons for discarding within this métier. Hake (MLS) and mackerel (quota exhaustion) are discarded due to legal reasons. Market reasons lie behind horse mackerel discards.

OTD mainly lands hake, anglerfish and megrim, but there are more than 65 other landed species (pouts, dogfish, triglids…). Total discards are around 60-65 % of the total catch. Hake individuals under MLS and pelagic species such as horse mackerel (*Trachurus trachurus)* and mackerel (*Scomber scombrus)*) are the main component of the discarded catch fraction.

OTM mainly lands squids, cuttlefish, and mullets are the main target species in this métier. However this is a very mixed métier including many other species (pout, seabass, hake…), most of them not subject to any TAC or MLS.

2. The fleet

2.1 Fleet Structure

The fleet is composed of trawlers of 24 to 35m length with base port in Ondarroa (Spain). They operate mainly in the Bay of Biscay (Ices Divisions VIIIabd), but depending on the year they have some trips to ICES sub-area VII and VI. The evolution of the fleet and its cost structure in terms of number of vessels are shown below:

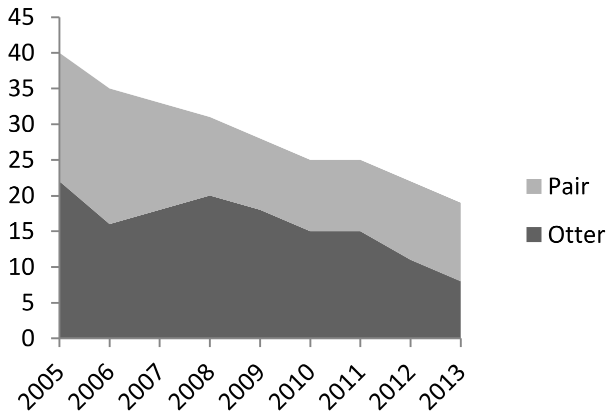


Figure 2. Evolution of the Basque trawlers operating in the Bay of Biscay. 2005-2013. Source: Eustat.

Table 1. Economic conditioning of the fleets considered in the simulation

		Units
Variable	**DTS**	**1000€**
Fuel Cost	1.240	€/days
Crew Cost	33%	% from the fishing income
Variable Cost	875	€/days
Fixed Cost	15.449	€/vessel/year
Capital Cost	64.438	€/vessel/year
Depreciation	20.952	€/vessel/year
Max days	150	days
FTE (direct)	11	FTE per vessel

Source: AER 2014. Note that given that these fleets also operate in the North Western Waters (ICES areas VI and VII), Fixed costs, capital costs, depreciation and max days have been weighted by the fishing days that these fleets exerted in the VIIIabd (BoB) in 2013.

2.2 Fleet Economics

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 633680

Table 1. Revenues obtained by this fleet. From 2010 to 2013 they are based on observations. In 2014 and 2015 are estimated based on the advice already observed for hake and megrim.

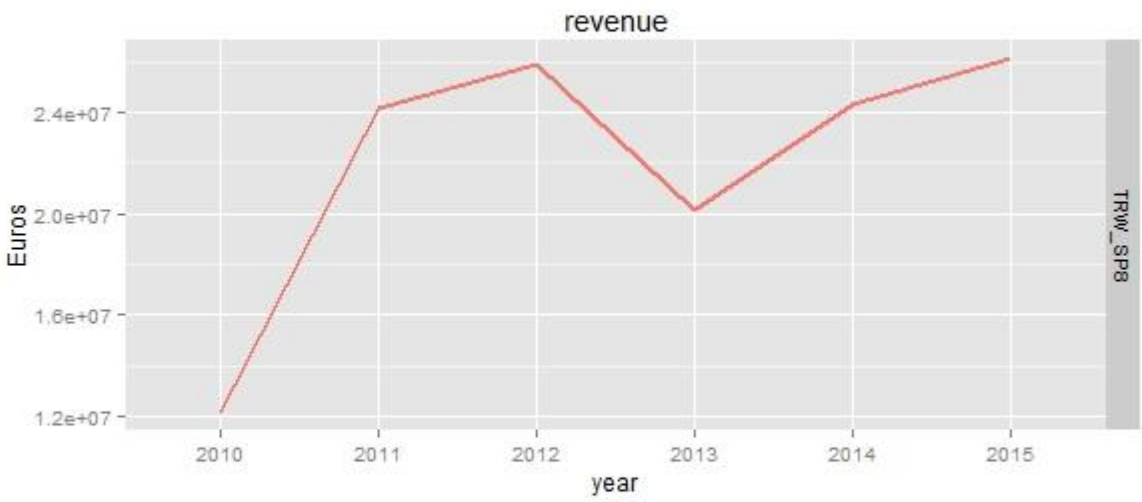
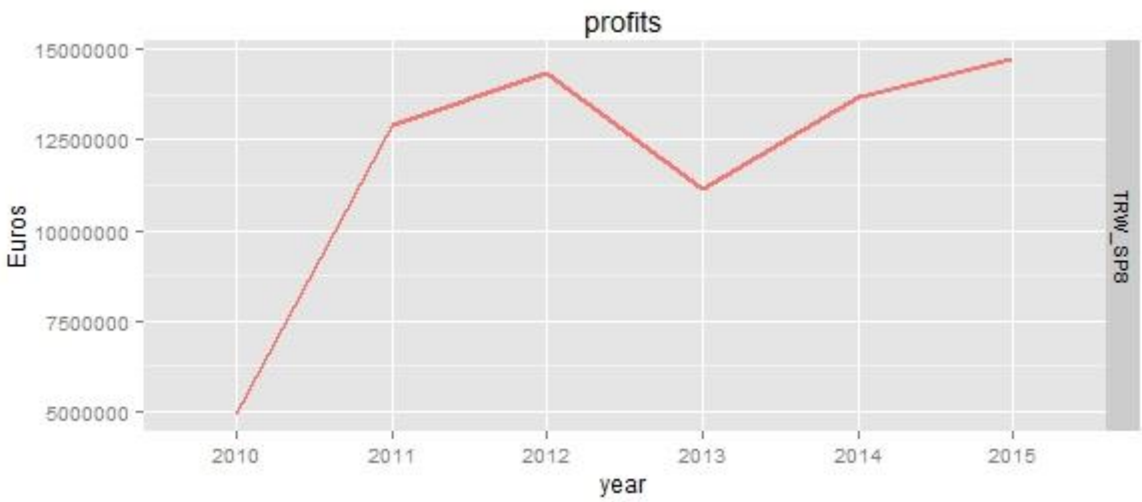
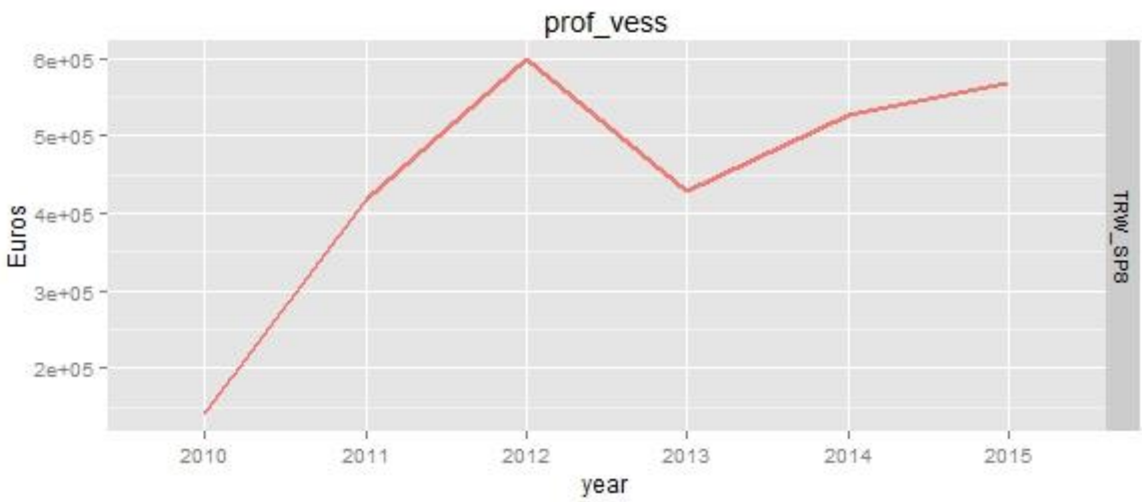


Table 2. Net cash flow obtained by this fleet. From 2010 to 2013 they are based on observations. In 2014 and 2015 are estimated based on the advice already observed for hake and megrim.



As it can be seen in the figures above, the net cash flow of the fleet is positive, but it is quite dependant on the fuel cost, which is the main cost element (excluding the crew costs)

Table 3. Net cash flow by vessel obtained by this fleet. From 2010 to 2013 they are based on observations. In 2014 and 2015 are estimated based on the advice already observed for hake and megrim.



2.3 Target and non target species

For explaining the catch composition of each metier up to 12 different stocks have been considered (see table below). The selection has been made in terms of the overall (fleet) importance of these stocks in terms of the catches and the income obtained from them.

Table 4. Stocks selected, name and average price (by age).

Code	Common name	Scientific name	Stock	Age	Average Price
ANK	Black anglerfish	*Lophius budegassa*	VI, VII, VIIIabd	all	5.53€
HKE	Hake	*Merluccius merluccius*	VI, VII, VIIIabd	<3	2.27€
HKE	Hake	*Merluccius merluccius*	VI, VII, VIIIabd	3	2.16€
HKE	Hake	*Merluccius merluccius*	VI, VII, VIIIabd	4	2.07€
HKE	Hake	*Merluccius merluccius*	VI, VII, VIIIabd	>4	2.89€
MEG	Megrim	*L. whiffiagonis*	VI, VII, VIIIabd	<7	4.02€
MEG	Megrim	*L. whiffiagonis*	VI, VII, VIIIabd	7	4.11€
MEG	Megrim	*L. whiffiagonis*	VI, VII, VIIIabd	>7	5.14€
MON	White anglerfish	*Lophius piscatorius*	VI, VII, VIIIabd	all	4.38€
HOM	Horse mackerel	*Trachurus trachurus*	Widely distributed	all	0.84€
MAC	Mackerel	*Scomber scombrus*	Widely distributed	all	1.68€

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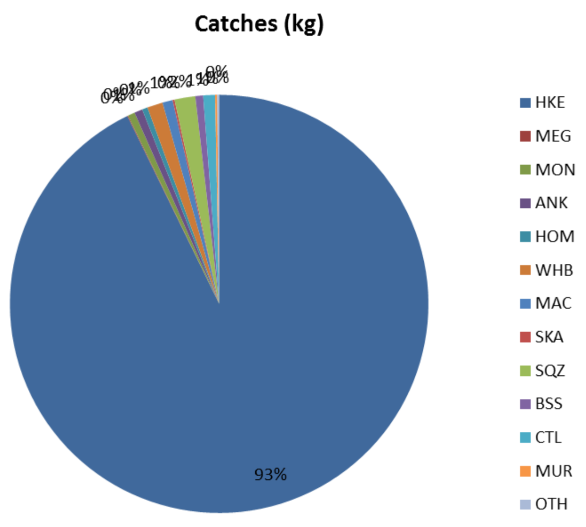
WHB	Blue Whiting	*Micromesistius poutassou*	Widely distributed	all	1.19€
MUR	Red Mullet	*Mullus surmuletus*	-	all	3.87€
SQZ	Squids	*Loliginidae*	-	all	5.71€
CTL	Cuttlefish	*Sepiidae*	-	all	3.29€
SKA	Skates	*Raja spp*	-	all	3.83€
BSS	Bass	*Dicentrarchus labrax*	-	all	7.14€
		Metiers			
OTH	Others	OTB_DEF_>70	-	all	1.16€
OTH	Others	OTB_MPD_>70	-	all	0.99€
OTH	Others	PTB_DEF_>70	-	all	1.96€

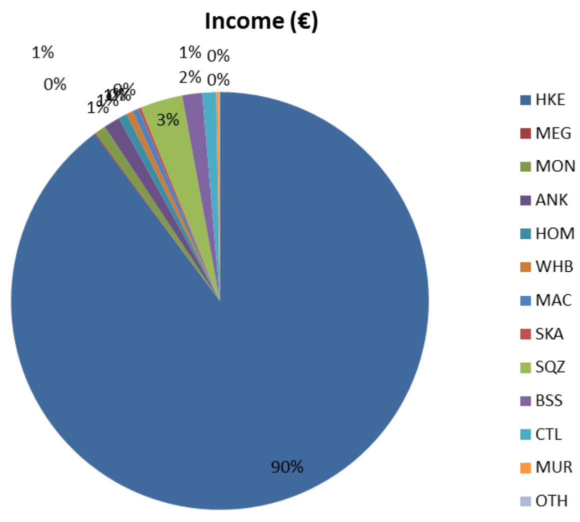
Table 5. Catches and values explained from 2011 to 2013 using the stocks selected

	2011	2012	2013
Catch	83%	83%	81%
Value	88%	89%	88%

All these stocks represent at least the 81% of the total catches and the 88% of the total income.

The figures below represent the importance of each stock by metier. As it can be seen PTB can be seen as single stock metier while OTD and OTM are pure mixed stocks.





This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 633680

Figure 3. Catches and income for the PTB metier

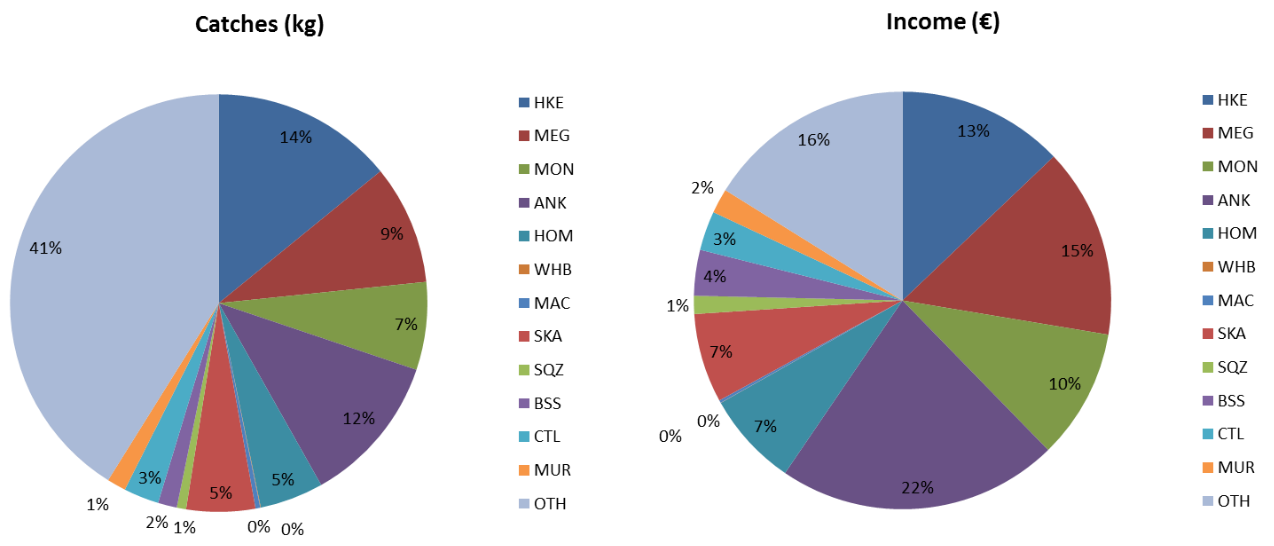


Figure 4. Catches and income for the OTD metier

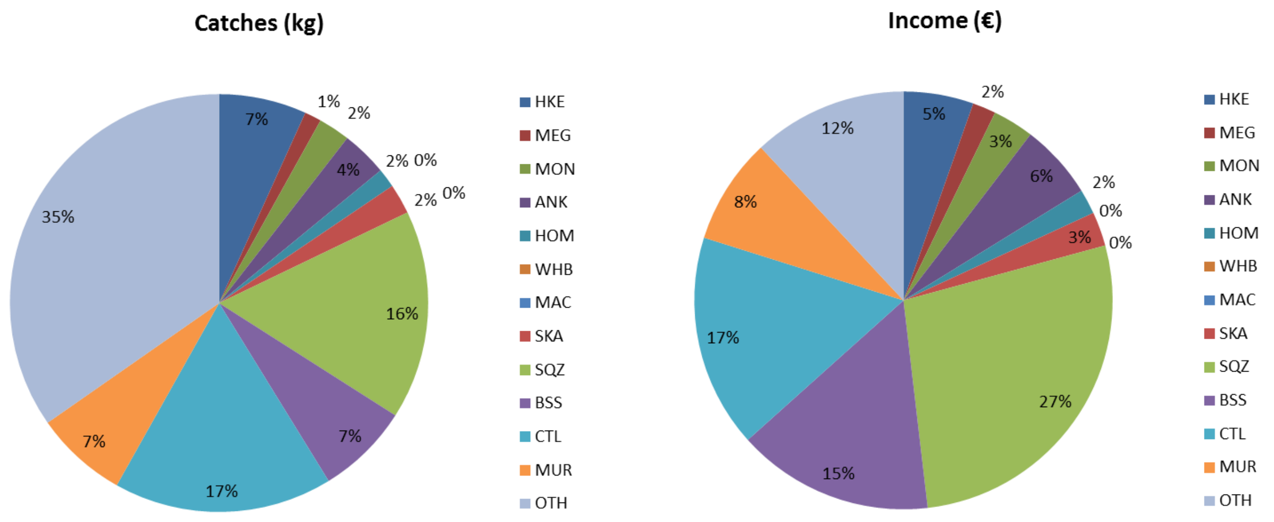


Figure 5. Catches and income for the OTM metier

3. Current management system

This fleet is managed through TAC and TAE, apart from some other technical and physical measures. These two regulations (TAC and TAE) come from different origins.

The TAC was first implemented when Spain joined the EU in 1986. Setting TACs involves the fixing of maximum quantities of fish that can be caught from a specific stock over a given period of time. This operation requires cooperation among the various parties enabling those involved to come to an agreement regarding TACs and an allocation key for sharing them. The EU went on to share fishing opportunities in the form of quotas among Member States. A formula was devised to divide TACs according to a number of factors, including countries' past catch record. This formula is still used today, on the basis of what is known as the principle of 'relative stability' which ensures Member States a fixed percentage share of fishing opportunities for commercial species. Even if the share has been maintained stable over time, the growing scarcity of the key stocks has eroded significantly the fishing opportunities for these fleets.

The TAE is previous to the TAC regulation. In 1981 it was decided to list all the Spanish vessels operating in Divisions VIIIa,b,d and Sub-areas VI and VII, in order to create the access rights to these fisheries (a single fishing right per vessel). The idea was to maintain fixed these rights even if the number of vessel decreased. When Spain joined the EU the number of vessels in that list was close to 300 and the so-called "300 list" was created. These fishing rights became transferable by area.

Finally, concerning technical measures, some mess size limitations and minimum landing sizes for some stocks have been implemented.

Further information on how this fishery is managed can be found in Iriondo et al. (2013), Prellezo et al. (2009) or in Prellezo (2010).

4. How LO will be implemented

Figure 6 is presenting how the simulation will be performed. From 2010 to 2013 we have observations so it will work as the initial conditions of the system. 2014 and 2015, we don't have data so these two years have to be simulated. Nevertheless given that we know the advice provided, we don't have to use any harvest control rule, but the real TAC advice and approved.

In 2016 it stars the real simulation process in where we will have two different routes for comparative purposes (see Figure below).

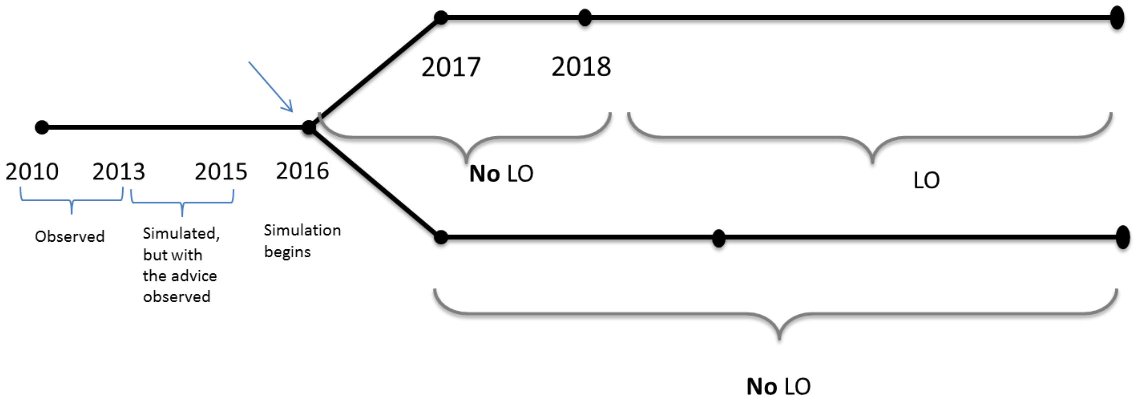


Figure 6. How LO will be implemented and compared

The southern route is simply a dummy one in where no LO is implemented.

The northern one is the introduction of LO in the system. This application will be implemented assuming that effort is limited by the first quota constraint so discards are not allowed. On top of that, and sequentially, some exemptions will be introduced.

- De minimis in where a 5% of the TAC can be discarded.
- Inter-year flexibility, with a limit of 10%.
- Inter species flexibility with a limit of 9%.
-

References

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ANNEX 1: Landings by species and métiers in 2013.

	OTB										OTM		PTB										
	ene	Feb	mar	abr	may	jun	sep	oct	nov	dic	feb	nov	ene	feb	mar	abr	may	jun	jul	sep	oct	nov	dic
ANK	1972	978	2388	6402	9062	7128	7795	5254	143	5505	986	893	1961	524	93	89	523	373	1088	470	457	2545	435
ARY	5100	3566	1520	2992	2569	1413	5642	5028	134	6239	3618	629	14	105	35	187	23	17		59	80	26	
BIB	361	349	412		177	355	794	737		189	223		330	125	83	11	117	65	244	34	225	34	97
BLL				5	9			5				4	71								2		21
BRF														10	82	132							
BSS	1411	559	374	64				940	422	1072	7974	720	2498	173	76						323	351	661
COE	802	1034	1422	439	250	270	1577	619	868	582	508	1179	519	116	268	81	205	41	43	49	160	95	68
CRE				571	219		1270																
CTB								78	86	4		189											62
CTL	2146	3319	3820	493				415	700	2513	933	8190	2617	364	990		23				3	47	3173
EOI	4536	2096	3125	4278	2362	1357	511	670	46	317	1066	75		8	5		11						
GAD	3308	1955	1298	1655	1364	2635	4504	2417	967	3193	2676	3242	1702	171	55	130	1226	393	930	231	1668	672	880
GFB														113	205	256		17	7				
GUX	755	1094	3391	1264	1675	3213	4986	3228	38	1647	372	143	2410	203	612	297	1064	551	1558	831	4022	3272	2963
HAD														11		36							
HKE	4663	2138	3932	3926	5280	3914	4497	2723		2513	2747	2136	44814	97623	230308	229575	158581	161322	182355	61720	119476	81877	14392
HOM	584		224	1006	420	2346	628	852	132	136		3144	1171	1055	436	1347	631	1729	758	92	510	285	
JOD	242	275	1248	1319	915	835	540	414	17	1018	11	102	786	1238	506	825	2451	1268	809	912	1601	646	392
LDB	1353	841	1054	782	450	1855	10000	5549	221	1081	19	85	37	0					0			1304	
LIN	10		46	63	9	48	34	41			13		12	81	21	34	14	2		9	9	7	18
MAC													17208										
MAS																			12				
MEG	5453	3454	4284	15363	10155	10989	1189	770	20	275	2243	75	271	19					6			1128	
MGR			33						743	64		213											
MON	1404	824	1136	1585	924	618	1137	858	43	1159	537	448	1881	345	217	129	707	256	124	116	394	4629	530

DiscardLess

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MUL								481	255			165											
MUR	491	248	609	1665	2304	626		333	159	607	111	2165	354			130	160	32			26		299
OCC												33											
OMZ			46	2600	1816	671							187	2711	1198	2933	838	284	57			765	
PAC									10														
POL	101	159	169	49	9		63	54		6			46	13	77	10	37	47	54	14	23	15	4
RJC	223	213	696	284	281	381	499	17		168	13	32	183	11	57	159	424	72	37			17	49
RJN	2147	783	3064	6029	1413	2231	3742	506		1654	902	191	150	9									
SBA												27									5		
SBG								42	17			10											
SBR															10	7							
SKA								1168		843		445	365	178	44	15	63	15		25	23	61	34
SOL	182	89	252	92	82	288					43		52										30
SOX								380	1858	1681	43	878											
SQZ	275	14	28	271				194	486	558	44	8529	3453	69	12	23					33	556	4197
SRG			10					10		5												14	
SYC	2162	2831	4764	3403	5977	6119	6422	4029	241	3716	1479	1538	4821	140	7	59					189	26	991
TRK	332	409	990	1789	772	518				241	387		351	119	210	223	1401	595	38	12		14	141
TUR		7		77	56	14				6	4	7					7				3		6
UCA									110	16	10	95	13										15
WEG								638		79		36	241				17		32	233	1288	365	689
WHB														70	333	1679	978	3981	3203	357	92		
WHG			94					634	266	135	35	498		7							7408	65	240

ANNEX 2: Codes

Code	Spanish name	Scientific name	English name
ANK	Rape negro	*Lophius budegassa*	Black-bellied angler
ARY	Peon, pez plata	*Argentina sphyraena*	
BIB	Faneca comun	*Trisopterus luscus*	Pout, Bib
BLL	Remol, Corujo	*Scophthalmus rhombus*	Brill
BRF	Cabra (Helicolenus dactylopterus)	*Helicolenus dactylopterus*	
BSS	Lubina	*Dicentrarchus labrax*	Bass
COE	Congrio (Conger conger)	*Conger conger*	Conger
CRE	Buey	*Cancer pagurus*	Edible crab
CTB	Mojarra	*Diplodus vulgaris*	Common Two Banded Sea Bream
CTL	Sepias y chocos	*Sepiidae*	
EOI	Pulpo blanco	*Eledone cirrhosa*	Curled octopus
GAD	Fanecas spp	*Trisopterus spp*	Pout, Bib
GFB	Brotola de fango (Phycis blennoides)	*Phycis blennoides*	Greater Forkbeard
GUX	Triglidos	*Triglidae*	
HAD	Eglefino	*Melanogrammus aeglefinus*	Haddock
HKE	Merluza europea	*Merluccius merluccius*	Hake
HOM	Chicharro Negro	*Trachurus trachurus*	Atlantic (Scad) Horse mackerel
JOD	Pez de San Pedro	*Zeus faber*	Atlantic John Dory
LDB	Gallo boscii	*Lepidorhombus boscii*	Four-spot megrim
LIN	Maruca, Juliana (Molva molva)	*Molva molva*	Ling
MAC	Verdel, Caballa	*Scomber scombrus*	Mackerel
MAS	Estornino	*Scomber colias*	Chub mackerel, Spanish mackerel
MEG	Gallo whiffiagonis	*Lepidorhombus whiffiagonis*	Megrim
MGR	Corvina	*Argyrosomus regius*	Meagre
MON	Rape blanco	*Lophius piscatorius*	Anglerfish, Monkfish
MUL	Lisas	*Mugilidae*	
MUR	Salmonete de roca	*Mullus surmuletus*	Red Mullet
OCC	Pulpo comun	*Octopus vulgaris*	Octopus
OMZ	Potas y voladores	*Ommastrephidae*	
PAC	Breca	*Pagellus erythrinus*	Pandora
POL	Abadejo	*Pollachius pollachius*	Pollack
RJC	Raya de clavos	*Raja clavata*	
RJN	Raya santiaguesa	*Leucoraja naevus*	Cuckoo ray
SBA	Aligote	*Pagellus acarne*	Axilary sea-bream
SBG	Dorada	*Sparus aurata*	Gilthead Sea Bream
SBR	Besugo	*Pagellus bogaraveo*	Red sea-bream
SKA	Rayas spp	*Raja spp*	Skates
SOL	Lenguado	*Solea vulgaris*	Sole
SOX	Soleidos	*Soleidae*	

SQZ	Calamares Loliginidae	*Loliginidae*	Inshore Squids
SRG	Esparidos	*Sparidae*	
SRG	Esparidos	*Sparidae*	
SYC	Pintarroja	*Scyliorhinus canicula*	Dogfish
TRK	Tolla, Musola spp	*Triakidae*	Tope shark, flake
TUR	Rodaballo	*Psetta maxima*	Turbot
UCA	Verrugato de fango	*Umbrina canariensis*	Canary drum
WEG	Salvario, Escorpion, Escarapote, Araña	*Trachinus draco*	Greater weever
WHB	Lirio, Bacaladilla	*Micromesistius poutassou*	Blue whiting
WHG	Merlan	*Merlangius merlangus*	Whiting

7.3 Appendix 3. Western Mediterranen summary (Javier González, Antoni Quetglas, IEO)

WESTERN MEDITERRANEAN CASE STUDY

by Partner 3-IEO (Javier González, Antoni Quetglas)

Introduction

Over recent years the global fishing industry has been under increasing pressure to reduce bycatch and discards, understood as the portion of a vessel's catch returned to the sea dead or alive (Condie *et al.*, 2014; Sigurðardóttir *et al.*, 2015). Discarding wastes human food and economic resources. It also represents a source of unaccounted mortality as long as this catch is unreported and mortality rates of releases is uncertain, increasing the uncertainty of stock assessments and contributing to the overfishing of European fish stocks (European Commission, 2011; Sigurðardóttir *et al.*, 2015).

The incentives for discarding are numerous, but in general result from multiple species and size of fish in the same area and being captured by fishing gear of limited selectivity (Condie *et al.*, 2014). However, discarding is not just an effect of non-selective fishing practices, but also a consequence of existing management regulations. Until 2014, EU fisheries regulation prohibited the retention of catch that exceeded catch quota, was of Minimum Landing Size (MLS) or did not meet catch composition regulations. Catch is also discarded if it is of poor quality, small size, non-commercial species or low market value. Discarding small-sized or non-commercial species to save quota and/or space for larger, higher priced individuals is known as "high grading" (García-Rivera *et al.*, 2015; Sigurðardóttir *et al.*, 2015).

Consequently, discarding is far from being an easy issue to solve, as it involves biological (environmental conditions, species biology, etc.), economic (absence/presence of markets, etc.), legal (regulations), and even social (community economy) and cultural values, customs and ethical considerations (Bellido *et al.*, 2011; García-Rivera *et al.*, 2015). With the objective of reducing unwanted catches and eliminate discards by 2019, the reformed Common Fisheries Policy (CFP—EU regulation1380/2013) introduced the obligation to land all catches. This represents a fundamental shift in the management approach to EU fisheries, switching from landings monitoring to catches monitoring (Damalas, 2015).

However, it is still uncertain the socioeconomic impacts that this new regulation will have on the affected European fisheries. A discard ban, included in a more general discard governing system managed on the basis of quotas and fishing effort control, has been already implemented in different countries outside the EU (Faroe Islands, Iceland, Norway) with satisfactory outcomes. However, discard management in such countries is less complex than it is in the EU (Condie *et al.*, 2014; García-Rivera *et al.*, 2015). Moreover, the European fishing industry is highly diverse, with significant differences between the North Atlantic and Mediterranean regions and, consequently, impacts of a discard ban will be dissimilar between different areas.

In order to assess the potential socioeconomic effects of the EU landing obligation in the Mediterranean fleets, a literature review on the economic and social aspects of discarding in Mediterranean fisheries has been carried out, identifying existing information and most important knowledge gaps.

Literature review

Research on discards and, more specifically, on the potential socioeconomic effects of the landing obligation regulated by the EU has drawn much attention in the recent years as the time of implementation approaches. Nonetheless, research on economic effects of the landing obligation is mainly focused on fisheries subjected to catch limits (TAC's or quotas), while little attention has been paid to Mediterranean fisheries. For example, Catchpole *et al.* (2014) and Cosgrove *et al.* (2015) carried out two ban trials or simulations to evaluate the socioeconomic consequences of the landing obligation on English and Irish fleets respectively. Conclusions are made on the drivers for discarding under the current management regime, on the practical considerations for landing all catches, the economic impacts of a discard ban, the potential impact on fishing mortality and the implications for enforcing the discard ban. Business as Usual (BAU) and Landing Obligation (LO) scenarios were tested to evaluate the impacts for the fleet of the new regulation using Cost-Benefit analyses.

Further pilot studies have been conducted in UK (Poseidon, 2013; Condie *et al.*, 2014, 2015). However, a key aspect of all these studies is what is called "choke" analysis: to evaluate the impacts of the landing obligation when the catch of a given species reaches its quota limit. These types of analyses are not replicable in the Mediterranean, as its fisheries are not managed through TAC's or quota limits.

In addition to different management measures, the Mediterranean Sea has a number of special features. Its continental shelf gives rise to a high diversity of species in coastal areas, favoring a multi-species fishing activity that takes place mainly in such areas. This results in highly varying fisheries in terms of catches, target species, sorting practices and quantities and composition of discards (Carbonell *et al.*, 2003; Sánchez *et al.*, 2007; Tsagarakis *et al.*, 2013). The great majority of such fisheries are managed by controlling fishing effort, and fishing tends to be a small-scale activity carried out by local fishermen making daily trips and using a variety of fishing gear (García-Rivera *et al.*, 2015). These special and varying features have to be taken into account when developing and applying models aimed at assessing the economic consequences of the discard ban across such a diverse fishing fleet.

It is necessary to point out that, at present, research in the Mediterranean regarding discards' management is in the characterization and evaluation stage, both in terms of discards ratios and factors influencing such discards, which is a previous step to the economic valuation of the landing obligation on Mediterranean fisheries.

Tsagarakis *et al.* (2013) carried out a broad literature review regarding existing knowledge of discards in the Mediterranean Sea. Firstly, the review focuses on quantitative information concerning fisheries discards in the Mediterranean, examining discards ratios (discards/total catch including retained and discarded). Such ratios are categorized per fishery type: i) bottom trawls, ii) purse-seines and pelagic trawls, and iii) small-scale fisheries. Regarding i) bottom trawls, there is a high range of discards ratios based on large-scale geographic and regional differences. Studies of otter trawls from Egypt, Syria, Turkey and certain parts of Italy report discards on total catch ratios no more than 20%, while trawl fisheries from Greece, Spain, the Adriatic and the Straits of Sicily present discards ratios between 30% and 65%. These differences are due to environmental characteristics (such as substrate type, depth, productivity, etc.), fishing practices (gear type and target species) and commercial preferences and local customs and values. High variability is also observed between different target/species or groups.

Purse-seines and midwater trawls (ii) are among the few gears in the Mediterranean that have clear target species. Purse-seines are generally characterized by low by-catch and discard rates. Target species in the Mediterranean purse-seine fisheries usually represents more than 90% of the catch and discards are mainly composed of marketable small pelagic species which were undersized or had low commercial values. Finally, iii) small-scale fisheries in the Mediterranean use a great variety of fishing gears and fishing practices, with different discarding ratios per métier. In general, artisanal fisheries are characterized by moderate or low discarding, despite the existence of some exceptions (e.g. gillnets for hake in the Ionian Sea and trammel-nets for spiny lobster in Tunisia and Spain). Although no economic data regarding the effects of the landing obligation is reported through this review, the reported data is of clear interest to conduct future economic calculations.

These discards ratios and the differences found between different regions and fishing gears are in line with discard ratios estimated by further studies published in or after 2013 and, hence, not included in Tsagarakis *et al.* (2013) review (Uhlman *et al.*, 2013, Damalas and Vassilopoulou, 2013, Catchpole. *et al.*, 2013, García-Rivera *et al.*, 2015). Actually, Uhlman *et al.* (2013) carried out a European synthesis of discard data collected on board commercial towed-gear equipped vessels operating under six different national flags, concluding that discard rates were more homogeneous across fisheries than regions, observing a stark contrast between rates in the Mediterranean Sea and other fishing regions. As it will be detailed below, these differences may be due to different natural and environmental conditions, but they are also related with different market and economic incentives.

In terms of fishermen's behavior regarding discarding practices, Tsagarakis *et al.* (2013) identified incentives and factors affecting discards. As aforementioned, discarding is driven by biological, environmental and socioeconomic aspects and constrained by legal and technical reasons. These factors normally act in a synergistic effect, which may be not easy to disentangle, especially in multi-specific fisheries like most Mediterranean ones. Nonetheless, identifying and understanding these incentives is crucial in order to be able to assess and evaluate potential socioeconomic effects of the landing obligation based on fishermen's behavior. In this study, Tsagarakis *et al.* (2013) followed Eliasen and Christensen (2012) factors' classification to identify the main drivers in the Mediterranean (Table 1).

Table 6. Factors, incentives and drivers affecting discards in the Mediterranean Sea. Source: Tsagarakis *et al.* (2013).

Category	Factors/Incentives/Drivers
Natural conditions influence	Species composition, abundance and size structure of the catch Biological invasions Life cycles of species Environmental factors (depth, seabed, productivity, etc.)
Community influence	Soak time, haul duration Sorting practices
State and regulation influence	Technical measures (gear selectivity) Spatio-temporal closures Minimum Landing Size (MLS) Control and enforcement
Market and economic drivers	Low or no economic value of catches Resource use related to socioeconomic factors Storage capacity of the vessel and sorting capacity of the crew

The identification of incentives or drivers affecting discards has been a common topic in discards' research over recent years. Catchpole *et al.* (2013) developed an approach to establish the relative contribution of different drivers of discarding behavior. The analysis, applied to data generated from observer programs from five EU countries including the demersal trawl fishery from the western Mediterranean, makes inferences on the main causes of discarding by partitioning the discards into four categories. These categories are based on the length at which the fish were discarded and the regulatory restrictions associated to each species-area-gear combination. The decision tree used in the analysis is shown in **Error! Reference source not found.**, and the four categories are summarized in REF _Ref422742056 \h * MERGEFORMAT **Error! Reference source not found.**.

Table 7. The four categories of inferred discard drivers. Source: Catchpole *et al.* (2013).

Market drivers	**Inconsistencies:** Commercial species landed at some point but discarded due to inconsistencies in market opportunities, inconsistent sorting or poor condition/damage to fish.
	No market: Fish below a Minimum Marketable Size (MMS) – mismatch between gear selectivity and marketable size. Also includes no-commercial species
Regulatory drivers	**Quota restriction:** Fish above MLS of MMS that is discarded as a response to quotas restriction: includes "high grading" practices and fish discarded because quota has been exhausted.
	Under MLS: Fish discarded below the Minimum Landing Size – Mismatch between selectivity of fishing practices and the minimum legal length.

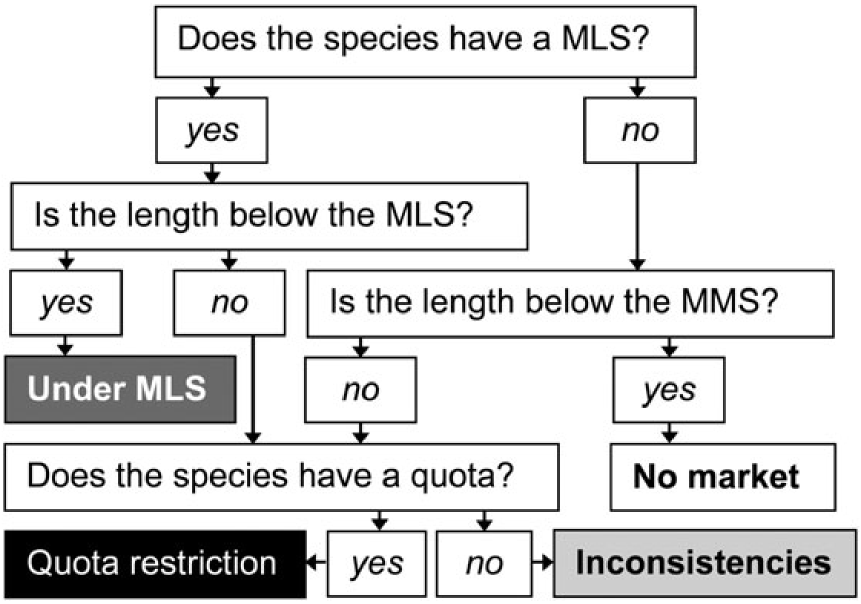

Fig. 7. Decision tree used to categorize the at-length discard estimated into the four inferred drivers of discarding. Source: Catchpole *et al.* (2013).

According to Catchpole *et al.* (2013), most of the discards of the trawl fishery in the western Mediterranean are driven by market factors, either inconsistencies or directly the lack of market or low commercial value. This result is in line with findings from all the studies reviewed referred to discards' drivers (Sánchez *et al.*, 2004; Damalas and Vassilopoulou, 2013; Tsagarakis *et al.*, 2013; Uhlmann *et al.*, 2013; García-Rivera *et al.*, 2015). The only species for which there is a documented relatively high discard rate driven by MLS regulation are hake (*Merluccius merluccius*), caught by Spanish trawl fisheries (Catchpole *et al.*, 2013; Uhlman *et al.*, 2013) and spiny lobster (*Palinurus elephas*), caught by Spanish artisanal fisheries (Quetglas *et al.*, 2004). For example, in another study carried out by Tzanatos *et al.* (2007) for the small-scale fishing fleet of Patraikos Gulf, low or no commercial value was the main reason for discarding (78% of the discarded weight).

This fact is highly relevant when assessing the socioeconomic effects of the landing obligation on Mediterranean fisheries. The landing obligation ('discard ban') included under Article 15 of the new CFP (CoM1380/2013) only prohibits the discarding of species subject to catch limits and those subjected to minimum size limits in the Mediterranean Sea. In this context, it is feared that the new regulation may have a little impact on Mediterranean fisheries, as most of the discards are driven by the lack of commercial value rather than being a consequence of MLS. García-Rivera *et al.* (2013) shown that in Santa Pola (Alicante, Spain), only 19% of the discards, in terms of weight, would be affected by the landing obligation, while the 81% remaining would continue being returned to the sea (discarded).

However, it is important to take into consideration that, as aforementioned, factors affecting discards are not easy to disentangle. Availability of resources ("Natural conditions influence") has been shown to affect market fluctuations and, thus, associate discarding practices in the Mediterranean (Sánchez *et al.*, 2007; Tsagarakis *et al.*, 2008). In multispecies fisheries, when catches of the primary target species are not satisfactory, species and sizes of lower commercial value are retained in order to compensate the income reduction from primary species. In this context, the obligation of landing species under MLS, making possible their sale for other uses than human consumption, may generate an additional income that could compensate for the lower catch of marketable species. Nonetheless, information regarding potential benefits (prices of undersized fish for fishmeal and industry demand) is needed to compare with the costs derived of handling, storage and landing the otherwise discarded fish.

Consequently, for an accurate assessment of the socioeconomic effects of the landing obligation it is necessary to identify and measure influence variables (e.g. environmental, biological, regulatory, market factors) which affect the nature and extent of discarding and use statistical modeling to control for these linked effects.

Another issue raised in the different reviewed articles is that of compliance with regulation. Although such issues are out of the scope of this review, in the future it will be important to take into consideration the level of compliance of existing regulations in the area in order to estimate the potential costs derived from control and enforcement measures. As Bellido *et al.* (2011) argued, the implementation of management measures must take into account the fishers responses. Thus, stock and discard assessments must extend to offering predictions of stock/discard trajectories under not only a range of possible management measures but a range of realistic outcomes in terms of compliance and enforcement of regulations.

Concluding remarks

- Mediterranean Sea has a number of special features that have to be taken into consideration when assessing socioeconomic effects of the new landing obligation regulation. Mediterranean fisheries are highly variable in terms of catches, target species, sorting practices and quantities and composition of discards.
- Discarding is driven by biological, environmental and socioeconomic aspects and constrained by legal and technical reasons. These factors normally act in a synergistic effect which may be not easy to disentangle, especially in multi-specific fisheries like most Mediterranean ones. It is necessary to identify and measure influence variables (e.g. environmental, biological, regulatory, market factors) which affect the nature and extent of discarding and use statistical modeling to control for these linked effects within the finally proposed models.
- Most Mediterranean discards are driven by market factors (low or non-commercial value of discarded species) rather than regulatory issues (MLS). In this context, it is feared that the CFP new regulation may have a little impact on Mediterranean fisheries.
- As revealed by the overview of collected information there are several gaps of knowledge regarding discards in the Mediterranean Sea. At present research in the Mediterranean regarding discards' management is in the characterization and evaluation stage. It is necessary to move from a descriptive to more analytic studies, aiming to disentangle incentives and factors affecting discarding, as well as to carry out socioeconomic valuations of the new CFP regulation on discards.

- It is required to carry out new studies and/or pilot projects to fulfill these knowledge gaps, especially those directed towards estimating discards affected by the landing obligation, existing markets for fish meal products and average prices and handling, storage and landing costs derived from the obligation to land discards subject to MLS.

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7.4 Appendix 4. Eastern Mediterranean summary (NAYS Ltd)

EASTERN MEDITERRANEAN CASE STUDY

by Partner 15-NAYS Ltd

Introduction

The reasons for discarding are numerous and highly variable. They can involve legal (e.g. species smaller than the Minimum Conservation Reference size, MCRS, previously named Minimum Landing Size), catches exceeding quotas, etc.), economic (low market value, high grading), technical (e.g. typology of fishing gear, vessel capacity), biological (e.g. species assemblages, life cycle characteristics) and environmental aspects (e.g. weather conditions affecting sorting practices) (Alverson *et al*., 1994; Stratoudakis *et al.,* 1998; Allen *et al.,* 2001; Machias *et al.,* 2001; Rochet and Trenkel, 2005; Tsitsika and Maravelias, 2006; Vassilopoulou *et al.,* 2012; Uhlmann *et al.,* 2013). These factors often act together, and it is quite difficult to separate them, especially in multispecies fisheries (Bellido *et al.,* 2012; Tsagarakis *et al.*, 2013).

Information from the fishing sector can be useful to get a perspective from the operators on discard practices and possible factors influencing them. In addition, this feedback is necessary to gather information on aspects related to the infrastructures onboard, which is difficult to access from other sources. In particular, this kind of information is useful to elucidate the possible occurrence of one of the two conditionalities for the application of the "*de minimis*" exemption, i.e. that consisting in avoiding disproportionate costs of handling unwanted catches, for those fishing gears where unwanted catches per fishing gear do not represent more than a certain percentage, to be established in a plan, of total annual catch of that gear.

Description of Thermaikos Gulf fishery

Northwestern (NW) Aegean includes the Gulfs of Thessaloniki (also known as inner Thermaikos) and Thermaikos as well as the gulfs of Chalkidiki Peninsula. Thermaikos Gulf is the main fishing ground, which is considered one of the most productive in the Greek Seas. Thermaikos Gulf is a shallow water area having a maximum depth of 50 m. Large river systems (Gallicos, Axios,Loudias and Aliakmon) discharge into Thermaikos Gulf about 207m^3/s, with significant temporal variability (Kallianiotis et al. 2004).

Fleet structure

According to the Fleet Register (KAM 2014), in 2014, 1460 vessels were registered in 7 ports of Thermaikos Gulf (Thessaloniki: 739 vessels; Skala Katerinis: 251 vessels; Nea Moudania: 232 vessels; Nea Michaniona: 82 vessels; Platamonas: 71 vessels; Agiokampos: 66 vessels; Stomio: 19 vessels). Based on the main gear used, 58 of these vessels are trawlers (using bottom trawls, OTB), 29 are purse seiners (using purse-seines, PS) and 1373 are small scale coastal vessels using a variety of fishing gears.

The fleet segment is defined by the gear code (FISHING_TECHNIQUE) and the vessel length (VESSEL_LENGTH which defines the minimum and maximum vessel length of fleet segment) category. The segmentation, which is defined in Appendices III (level 2), VIII (level 3) and X (level 4) of the Commission Regulation 1639/2001, of the Thermaikos fleet is shown below (Table 1).

Table 1.The number and LoA of fishing vessels per fleet segment in Thermaikos Gulf based on Fleet Register (KAM 2014).

Vessel category	**Segment**	**Number**	**Mean Length Overall (LoA,**	**Mean GRT**
Trawlers (OTB)	VL0012	0	-	-
	VL1224	14	22.67	59.78
	VL2440	44	28.30	129.75
	VL40XX	0	-	-
Purse seiners (PS)	VL0012	0	-	-
	VL1224	17	20.81	46.27
	VL2440	12	27.15	98.33
	VL40XX	0	-	-
Small-scale coastal vessels (various)	VL0012	1365	6.66	1.75
	VL1224	8	13.60	13.67
	VL2440	0	-	-
	VL40XX	0	-	-
Segment codes: VL0012 = less than 12 m in length; VL1224 = between 12 and 24 m in length; VL2440 = between 24 and 40 m in length; VL40XX = greater than 40 m in length				

Fleet economics

The total income of the Greek Fishing fleet reached 421.819.854 Euros in 2013 and by 99% are comprised from the sales of the catch. From the data of the following Table 3, there is no net profit for the fishing fleet in 2013.

Table 2 is presenting the main socio-economic performance indicators by fleet segment in the Greek national fishing fleet in 2012 by length class.

At this stage the fleet economics for the area of Thermaikos Gulf are not available.

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Table 2. Main socio-economic performance indicators by fleet segment in the Greek national fishing fleet in 2012.

		DTS 6-12	DTS 12-18	DTS 18-24	DTS 24-40	HOK 12-18	PGP 00-06	PGP 6-12	PGP 12-18	PS 12-18	PS 18-14	PS 24-40
Capacity	Number of vessels	236	32	120	184	152	5,866	9,037	184	91	131	30
	Gross tonnage (GT)	1,303	476	6,098	22,228	2,995	3,899	24,936	2,944	2,136	6,329	2,868
	Engine power(kW)	12,859	3,415	31,956	53,671	14,907	54,374	220,331	16,001	12,710	27,009	8,407
	Average length (m)	10	13	21	28	14	5	8	14	16	21	27
	Average age (years)	47	44	32	19	20	30	24	20	38	22	13
Employment	Total employed	748		640	1,012	494	8,267	13,513	342	637	1,524	383
	FTEs	328		640	753	443	5,882	13,513	342	572	1,214	257
Effort	Energy consumption (lt)	835.4		13,997.9	32,018.2	2,639.9	11,171.0	38,277.1	1,440.1	3,242.9	8,481.6	2,992.4
Expenses (thousand €)	Wages and salaries	424		7,133	16,338	3,210	5,230	18,959	2,203	4,091	10,408	5,371
	Imputed value of unpaid labour	785		315	600	550	27,875	60,029	451	319	150	15
	Energy costs	907		12,275	23,162	1,992	14,319	42,331	1,418	2,897	7,583	2,171
	Repair and maintenance costs	665		1,968	4,135	715	7,255	18,569	705	846	4,739	547
	Variable costs	559		6,525	12,073	4,350	7,944	26,237	1,874	3,423	16,328	4,606
	Non variable costs	108		1,236	1,291	159	792	2,955	96	179	804	131
	Annual depreciation	1,210		3,193	9,013	1,699	4,253	26,330	1,604	1,593	3,033	1,586
Capital value (thousand €)	Fleet depreciated replacement value	3,959		11,948	36,682	7,820	17,438	116,140	7,524	5,802	11,874	6,885
	Investments	722		358	940	739	6,804	17,543	981	104	1,725	292
	Financial position (%)	0		21	7	25	0	4	7	0	14	0
Performance indicators (thousand €)	Operating costs (excluding unpaid labour)	3,872		32,331	66,012	12,124	39,793	135,381	7,900	13,029	42,895	14,411
	Operating costs	4,657		32,645	66,613	12,674	67,668	195,410	8,351	13,348	43,046	14,427
	Total Income	4,148		35,880	76,091	17,104	65,473	166,256	7,267	17,950	29,706	7,962
	Net profit plus imputed value of unpaid labour	276		3,549	10,079	4,979	25,680	30,875	-633	4,921	-13,189	-6,450
	Net profit	-509		3,235	9,479	4,429	-2,194	-29,154	-1,084	4,602	-13,339	-6,465

Source: STECF 2014 Annual Economic Report on the EU Fishing Fleet.

Table 3. Greek national fishing fleet economic performance indicators in 2013.

	Value (€)	**% Total cost**
Crew wages	105.420.429	21,97
Unpaid labour costs	80.058.019	16,68
Energy costs	108.188.604	22,55
Repair and maintenance costs	43.168.187	9,00
Other variable costs	77.604.070	16,17
Other non-variable costs	6.747.994	1,41
Annual depreciation	58.675.084	12,23
Total Cost (excluding annual depreciation and crew wages)	**341.129.284**	
Total Cost (excluding annual depreciation)	**421.187.303**	
Total Cost (excluding crew wages)	**399.804.368**	
TOTAL COST	**479.862.387**	100,00
Revenues from landings	418.072.659	
Direct subsidies	3.747.195	
Revenues from landings	**421.819.854**	
Profit and wage from labour	**22.015.486**	
Net Profit	**-58.042.533**	

Target and non-target species

Trawlers

The most abundant species in the bottom trawl catches in Thermaikos Gulf are red mullet *Mullus barbatus*, cuttlefish *Sepia* spp., spottail mantis shrimp *Squilla mantis*, caramote prawn *Melicertus kerathurus*, deep-water rose shrimp *Parapenaeus longirostris*, musky octopus *Eledone* spp., anglerfish *Lophius* spp., European hake *Merluccius merluccius*, spotted flounder *Citharus linguatula*, and octopus *Octopus* spp. (Apostolidis et al. 2013). Red mullet and surmullet *Mullus surmuletus*, caramote prawn, deep-water rose shrimp, European hake, cuttlefish and octopus are the main target species of the trawl fishery in Thermaikos Gulf.

The number of non-target species is high including various species of the families Gobiidae, Labridae, Serranidae, Soleidae, Triglidae, among others (Karachle 2008).

Purse seiners

Anchovy *Engraulis encrasicolus*, sardine *Sardina pilchardus* and Atlantic chub mackerel *Scomber colias* are the main target species in the area. The catch of non-target species is very low.

Small-scale coastal vessels

The small-scale coastal fleet of Thermaikos Gulf targets a wide variety of species some of which are also targeted by the trawling fleet (e.g. red mullet and surmullet, and caramote prawn) and one by the purse seiners (European sardine).

Current management system

The activities of trawlers, purse seiners and small-scale coastal vessels as well as recreational fishing are regulated by the Presidential Decree (P.D.) 68/2009 (Government Gazette No. 90, Part I, 12 June 2009, pp. 5127-5130) entitled "Regulation of fishing in the gulfs of Thessalonica and Thermaikos". The general fisheries regulations for the Greek seas, based on the European legislation, are valid unless stated or specified otherwise in the P.D. 68/2009.

This Decree regulates the overall fishing activities within the major two gulfs in the region, Thessalonica and Thermaikos gulfs. It sets forth provisions for the allowable fishing gears and methods, provides specifically for trawling fishing (art.3: bottom trawling is prohibited in Thessaloniki Gulf; in Thermaikos Gulf, bottom trawling is prohibited within 3 nm from coastline or 50 m depth should that depth is reached at shorter distance, and within 2 nm from the coastline regardless sea depth and over seagrass beds), purse-seining (art. 4: prohibited in Thessaloniki Gulf; in Thermaikos Gulf, purse-seining is prohibited within 300m from coastline or 50 m depth should that depth is reached at shorter distance), nets (art. 5: minimum stretched bar length is set at 36 mm, except for sardine nets in which it is set at 16 mm), fishing with light (art. 6: caramote prawn fishing is prohibited between January the 1st and July the 10th, and between the 11th and the 30th of September), mollusk fishing with traps (art. 7: each vessel is allowed to carry 500 pairs of fykenets or 300 traps), semi-permanent nets in the sea (art. 8), artisanal fishing (art. 9). It also makes provisions for fishing near the estuaries of rivers and for mollusk cultivation (art. 10). In article 11 are described the provisions regarding the marking of fishing gear. Some spatial restrictions also apply for trawling, purse-seining, and netting within Thermaikos Gulf.

Regarding recreational fishing, spear fishing is completely prohibited and each fisher/boat is allowed to fish less than 3 kg of fish and cephalopods per 24h.

LANDMED results on discards

A recent report from the LANDMED[1] project (Lembo, 2014), presented interesting socioeconomic aspects from the Mediterranean Sea (including Greece) and focused on the current size/structure of the vessels, on the organization of the fishing operations and room onboard the fishing vessels (purse seines) as well as information on infrastructures at ports or landing sites to manage the landed discards.

Results from the questionnaires, distributed to 105 stakeholders from Italy, Spain and Greece, is reported in Figure 1. For the large majority of stakeholders (86%) the target species was anchovy, followed by sardine. In order of priority the second target species was sardine (74%), followed by anchovy (5%), but for 10% of stakeholders there is only one priority species, which

[1] Implications of the Implementation of the Landing Obligations Provisions in Small Pelagic Fisheries in Mediterranean (Landmed).

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is anchovy. This group did not mention any additional species. About 33% of the stakeholders mentioned a third target, which was sardinella, followed by Atlantic chub mackerel, though about 27% did not mention a third target. A considerable percentage of stakeholders (30%) has not a fourth target, however about 26% indicated Atlantic chub mackerel, while 13 and 12% respectively bogue and frigate mackerel. About 37% of the stakeholders did not mention a fifth target, whilst about 32% indicated horse mackerel followed by 10 and 8% that declared respectively Atlantic chub mackerel and bogue.

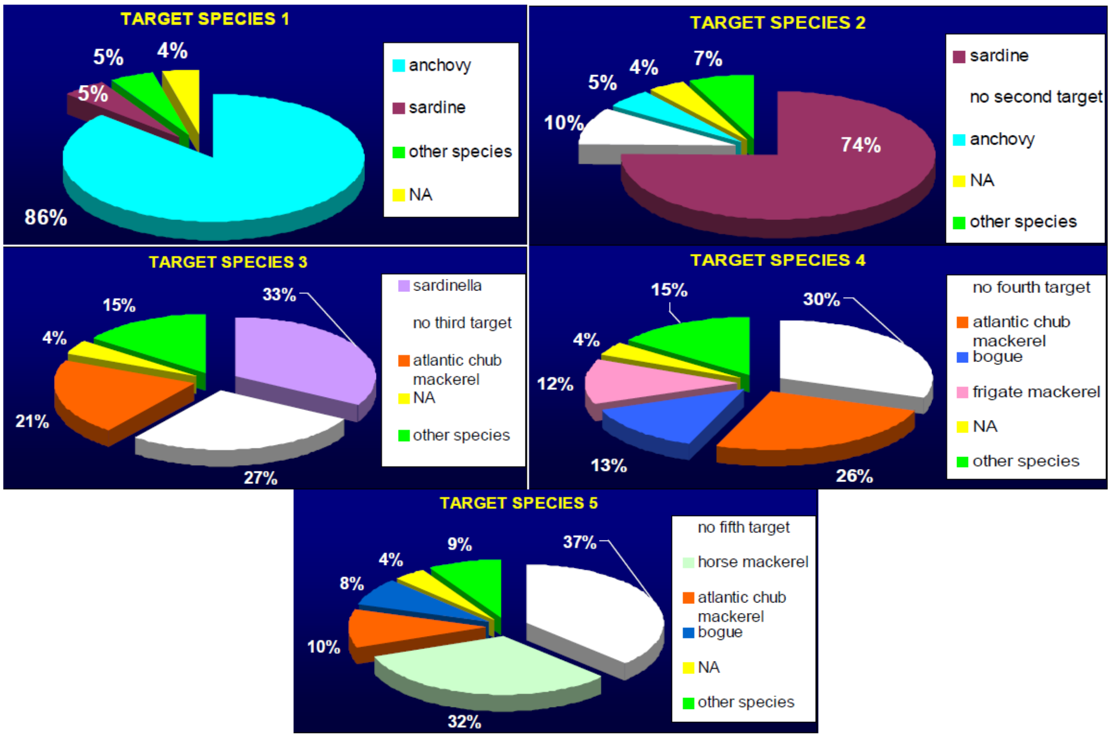

Figure 1. Qualitative evaluation of the target species ranking by stakeholders, according to a scale with five priorities. *Source: LANDMED project*.

Figure 2 summarizes the perception of the stakeholders regarding the amount of discards expressed as percentage of landings. About 19% of stakeholders, regardless of the vessel LOA, perceive an amount of discards that is 0, while the major part (28%) approximately evaluate the amount of discards between 1 and 2%. As a second ranking, about 16% of stakeholders, mainly related to vessels with LOA 12-18, gives an approximate evaluation of discards between 5 and 6%. Only 5% of stakeholders perceive the amount of discards larger than 10% and maximum 15% of the landings.

Figure 3 summarizes the perception of the stakeholders regarding the reasons for discarding. These reasons are ranked according to a scale of three priorities. The first priority reason that the stakeholders perceive is the low market value which has been indicated by 44% of the interviews. For 21% there is nor any reason for discarding, because the discard is quite close to 0. Damaged fish are perceived as a first priority reason for discarding by 16% of stakeholders, though it seems that the two reasons (low market value and damaged fish) are to a certain extent correlated. Minimum legal size and unwanted species catches account for the same percentage (7%). The second priority reason, besides the category "no other reasons" due to the

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fact that most did not give any additional cause for discarding other than the low market value, was again the low market value, followed by the minimum legal size (9%). The third priority reason was practically not populated as the main factors were represented as first and second priority reasons. If the overall answers are considered the most frequent was "no reason for discarding because there is no discard" (35%), the second one "low market value" (31%) and the third one "damaged fish" (about 10%).

	LOA					
Perception of the amount of discard (% of the landed fishery catches)	0-6	6-12	12-18	18-24	24-40	Total by discard class (in %)
0			3.8	6.7	8.6	19.0
0-1%			2.9	11.4	3.8	18.1
1-2%		1.9	6.7	13.3	6.7	28.6
2-3%			1.9	1.9	3.8	7.6
3-4%				1.0		1.0
4-5%						
5-6%		1.9	9.5	3.8	1.0	16.2
10-15%	1.0		1.9	1.0		3.8
15%			1.0			1.0
NA				1.0	3.8	4.8
Total by LOA (in %)	1.0	3.8	27.6	40.0	27.6	100

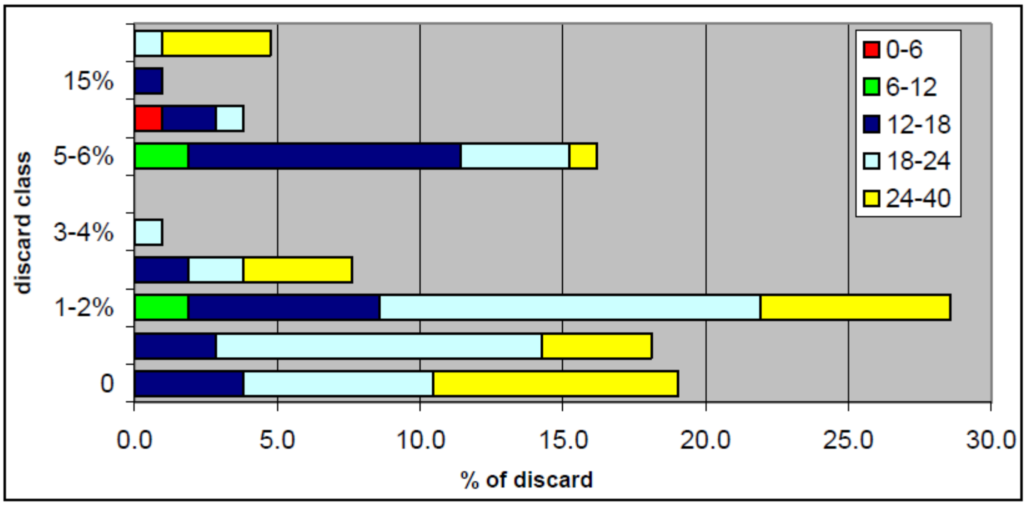

Figure 2. Perception of the stakeholders of the amount of discards expressed as percentage of landings. Classes are grouped on the y axis. *Source: LANDMED project.*

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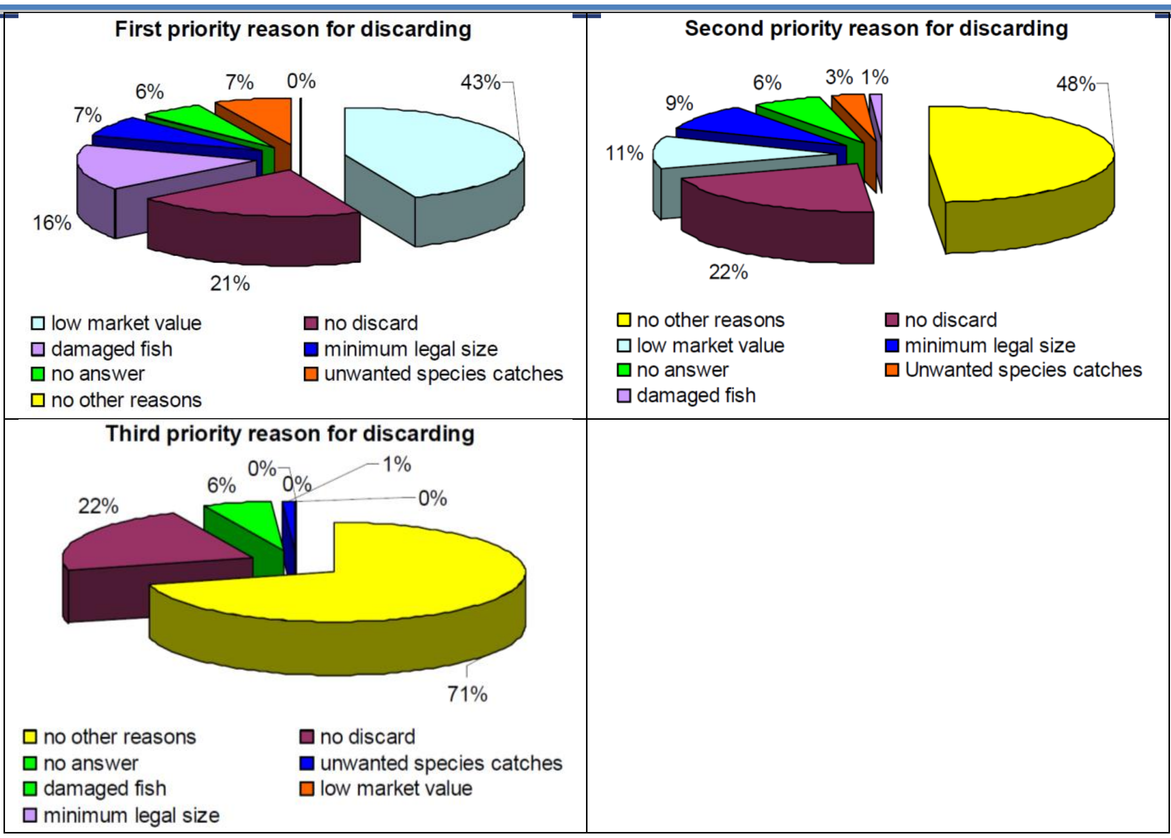

Figure 3. Perception of the stakeholders of the ranked reasons for discarding, according to a scale of three priorities. *Source: LANDMED project*.

The vessels with LOA lower than 6 m, which are very few in the fleets, have no facilities onboard, while those in the LOA 6-12 have a small dry storage capacity and none cold store and/or freezing capacity. These vessels have small trip duration and in general sell the product at the arrival to the port. They usually use ice during the fishing operation, after handling the catch, though they do not have an ice machine onboard. Thus their capability of storing additional catch can be considered very limited, especially as it is necessary to keep separate discards and landings.

The vessels in the fleet segment 12-18 m LOA have a higher dry storage capacity compared to the 6-12 m LOA ones and in Spain and Greece a better cold storage capacity compared to the same fleet segment in Italy (See Table 4). This is probably because the catch manipulation in the different areas is different, as for example Italian fleet makes much more use of an ice machine onboard. In the fleet segment 18-24 m the dry storage capacity increases in all the areas, but still the cold storage capacity is not a feature indicated by all the interviewed stakeholders, though the percentage of equipped vessels increases, from 50 to 90%. However, this kind of vessels also handle a larger catch, which in terms of landings can vary by country, and is estimated approximately at 1-2 tons. In the fleet segment 24-40 m LOA all the interviewed stakeholders indicated the presence of a cold storage room onboard besides a dry storage one. However, even in this case the catch is higher (approximate estimate of 2-3 tons per day), thus requiring more space even to keep differentiated the landings from the discards.

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The presence of structure for storage/freezing unwanted fishery catches was indicated by the 91% of the Greek stakeholders, who declared that storage/freezing structure to keep unwanted fishery catches are absent, while only about 2% indicated the presence of a structure close to the port area and 7% had no knowledge.

Table 4. Main characteristics of the infrastructures onboard the fishing vessels targeting small pelagics by vessel length and country. The number of interviews is also reported. The percentage indicates the frequency of positive answers.

ITALY	How many bunks for the crew?		Available working surface		Dry storage capacity		Cold store/store for freezing		Ice machine (%)	N° Interview
LOA		%	in boat deck (m^2)	%	Average (m^2)	%	Average (m^2)	%		
0-6	-		-		-	-	-	-	-	-
6-12	-		8.3	100	2.7	100	-	-	-	3
12-18	4	69	21.8	100	15.3	92.3	14.5	23	30.8	13
18-24	5	75	20	100	18	100	8	50	75	4
24-40	13	100	54.6	100	37.7	71.4	31.1	100	100	14

SPAIN	How many bunks for the crew?		Available working surface		Dry storage capacity		Cold store/store for freezing		Ice machine (%)	N° Interview
LOA		%	in boat deck (m^2)	%	Average (m^2)	%	Average (m^2)	%		
0-6	-		6				2			1
6-12	-		6		6					1
12-18	11	100	30.6	100	26.2	80	7.5	80	-	5
18-24	13	100	52.6	83	28.8	100	7.4	83		6
24-40	14	100	65	100	45	100	20.3	100		3

GREECE	How many bunks for the crew?		Available working surface		Dry storage capacity		Cold store/store for freezing		Ice machine (%)	N° Interview
LOA		%	in boat deck (m^2)	%	Average (m^3)	%	Average (m^3)	%		
0-6										
6-12										
12-18	9	100	22.5	100	14.3	27.3	8.6	100	-	11
18-24	11	100	38.1	100	17.3	62.1	18.8	90.6	3.3	32
24-40	14	100	43.3	100	19.6	90	32.9	100	0	12

Source: LANDMED project.

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7.5 Appendix 5. Iceland summary (Sigríður Sigurðardóttir and Jónas R. Viðarsson, MATIS)

Iceland. Sigríður Sigurðardóttir and Jónas R. Viðarsson

- Brief presentation of the CS and fisheries concerned

The individual transferable quota system (ITQ) has been in effect in Iceland since 1984, and like most other fisheries management regimes, it can generate an incentive for discarding catch. However, there is a discard ban in place in Icelandic waters. It is obligatory to land all catch with the exception lumpsucker that is alive in hauled nets and all halibut (*Hippoglossus hippoglossus*) catches that are belied to be able to survive. Moreover, it is permitted to discard worthless fish, intestines, fish heads and other things alike that results from on-board handling. Few exceptions are to that rule, such as factory trawlers that are obliged to land a portion of cod heads. So in practice, the landing obligation only applies to catches that have potential commercial value.

The level of discarding and estimation of the amount of discards has been controversial. In general, discards have been seen as an unfortunate but rather small problem in large scale fisheries in Iceland. Discards are primarily noticeable in the demersal fisheries, and are only estimated for cod and haddock; the two most valuable species and the species most commonly characterised as choke species.

Latest estimates for discarding are since 2012. Discards were low in 2012 in all gears, or 0-0.71% of landed catch. Total cod discards were 0.41% of landed catch and total haddock discards 0.08%

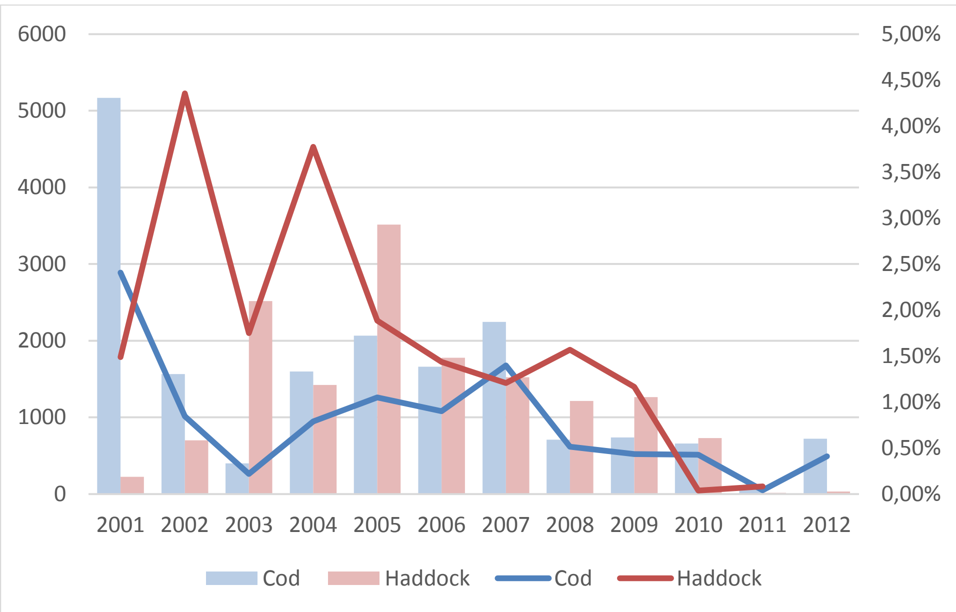

Figure 8: Discard estimates for cod and haddock (Pálsson et. al, 2013).

- Causes of discarding

The main reason for discarding is high-grading which result from the ITQ system – so the cause can be classified as legislative. For example, there are some indications of discarding of cod in the lumpsucker fishery. Although this has not been thoroughly investigated, it seems that in some cases cod is not caught by those lumpsucker fishers who don't have cod quota, despite other vessels in same area are catching cod at the same time. Recently, small boat owners have been complaining about too much haddock close to the coast where the small boats operate and too little quota at the same time[2].

During the early years of the ITQ system (1991-2005) there were a considerable part of the Icelandic fishing fleet that rented a substantial part of the quotas they fished. Most of these vessels were owned and operated by their captains, larger part of the crew. The ITQ rental fee was an incentive to high-grade and/or discard chock species. Over the past 10-20 year these vessels, relying on rental quotas, have sized operation and have been bought up by larger seafood companies. As results, almost all of the Icelandic fleet is now owned by relatively few companies that have adequate quotas and the crewmembers do not have private financial incentive to discard.

- Effects of discarding
    - Mortality of discards and escapees
    - Ecological effects of discarding
    - Economic effects of discarding

There have been done some experiments on mortality of discards and escapees in Icelandic waters (Pálsson et al 2003) but these studies have been far apart and focused on few species. Ecological and economic effects of discarding have not been studied much in Icelandic waters, since discarding is illegal.

- Discard Data
    - Discard sampling
        - How are they collected and used (in assessment/management)?
        - Coverage of total effort
        - Fisheries covered
    - Measuring Discards
        - Discard rates/ ratios
        - Total discards
        - Discard Indicators

Systematic collection of data in order to estimate discards has not been carried out in Icelandic waters. The discards are estimated with statistical methods, based on landing data and length data. Observers have however during the decades made length measurements of fish on board commercial vessels but the aim is to minimize the catching of undersized fish. The data used to evaluate discards are those length measurements at sea and landings data. The data collection is

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[2] http://www.smabatar.is/2014/01/ysukvoti-krokabata-a-klarast.shtml

mainly directed towards long-line, gillnet, Danish seine and trawl fisheries for cod (*Gadus morhua*), and long-line and trawl fisheries for haddock (*Melanogrammus aeglefinus*). In addition, the species composition of landed catch is viewed in relation to quota status and other factors.

- Methods for reducing discards
    - Discard ratios
    - Total discards

The Icelandic ban on discarding has been coupled with the establishment of a "bycatch bank" in 1989 which operated for a few years. The primary aim of the bank was to demonstrate to fishermen and the fish trade that there were markets for unusual species of fish caught as bycatch and where necessary introduce and promote those new species to consumers. This was done by such activities as "strange fish weeks" in restaurants, manuals which assist in identification of new species and recipe booklets. The bank organised to purchase blocks of frozen fish of normally non-commercial species from fishing boats, arranged taste panels, promotion schemes and sales to restaurants etc. As a result fish such as megrim, witch/pole dab and rough dab are the subject of specific fisheries in Iceland and a number of others such as starry ray (*Raja radiata*), great silver melt (*Argentina silus*), grenadiers (*Macrouridae*) and piked dogfish (*Squalus acanthias*) are caught and traded through normal channels, with other species such as Portuguese shark (*Centroscymnus coelolepis*) showing potential for market expansion.

Technical measures to mitigate and/or avoid discards include grids in trawlers that let the smaller fish easily escape, escape panels and T90 netting (turned mesh netting) which also improves size selection. In demersal fisheries, the minimum mesh size is 155 mm in the cod-end and 200 mm elsewhere.

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