The Economics of landing obligation: Aspects of Implementing the EU Landing Obligation

Peder Andersen and Lisa Ståhl

Department of Food and Resource Economics
University of Copenhagen

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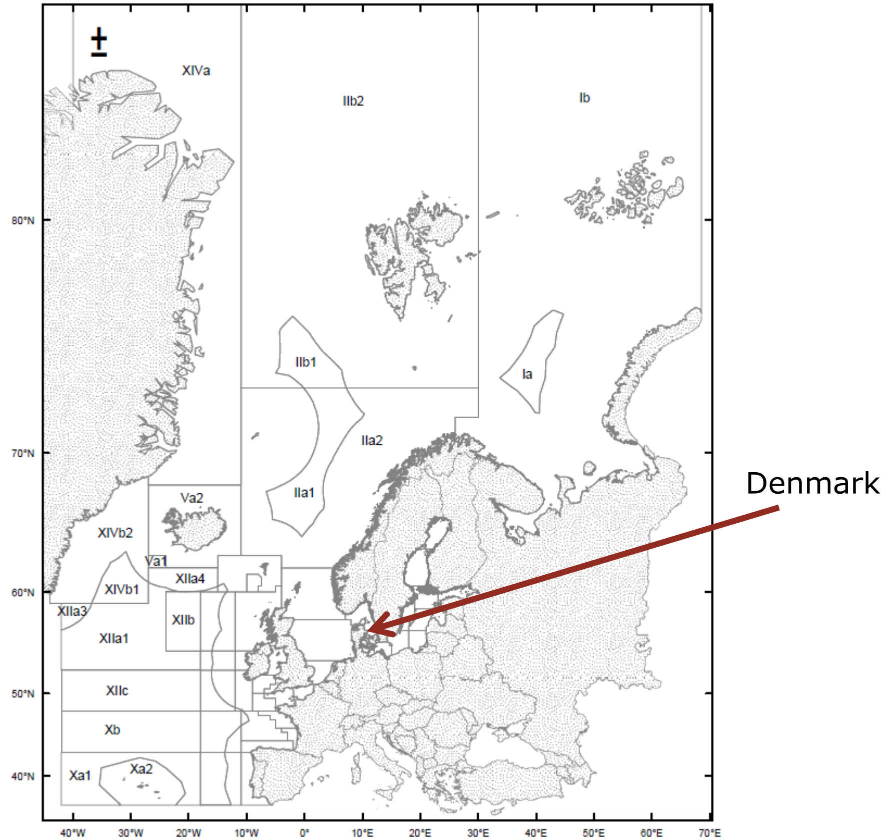


The landing obligation

The European Union (EU) fishery policy reform in 2013 included a landing obligation/a discard ban

Main motivations for the EU landing obligation (L.O.):

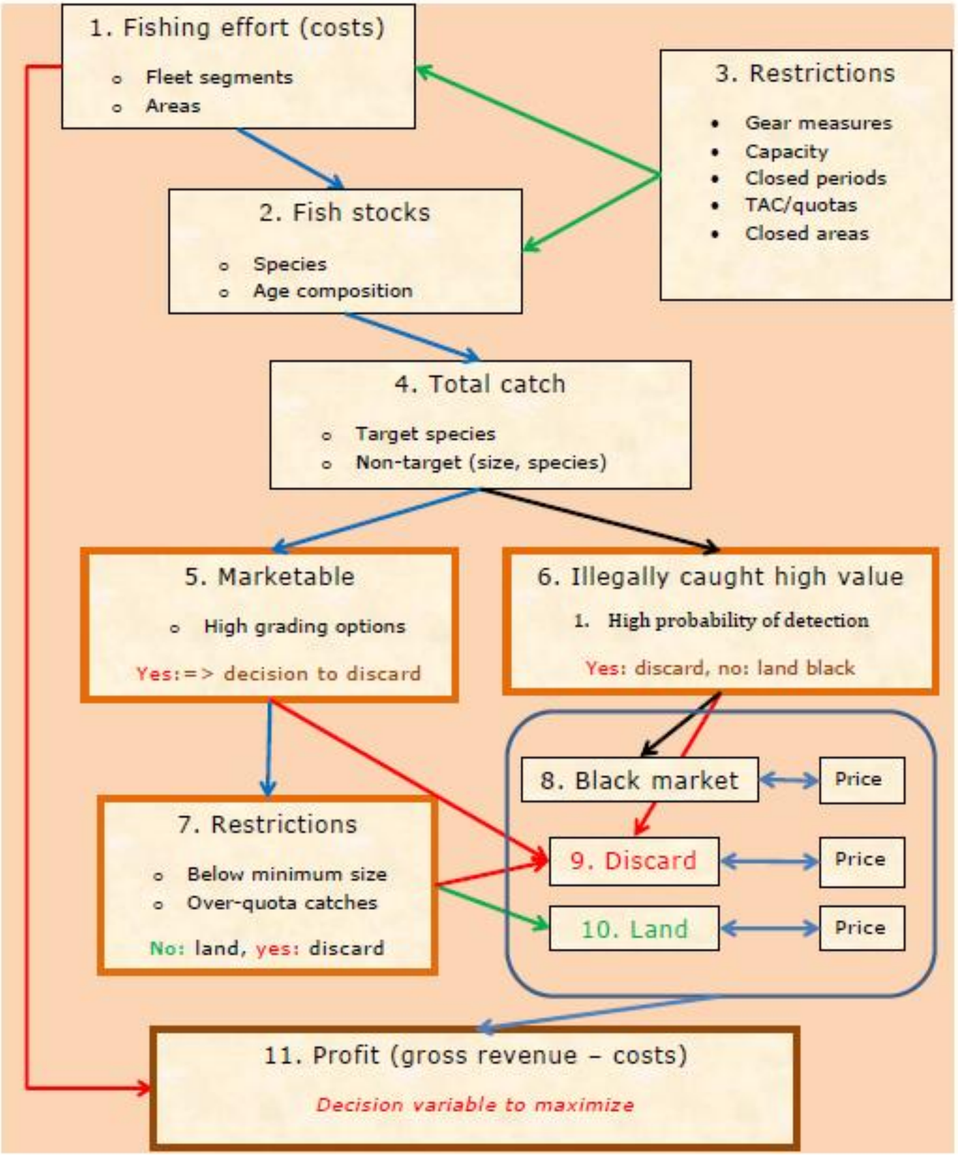
- Ethical: Reduce resource waste
- Biological: More healthy fish stocks and more healthy ecosystems by increased selectivity

There is much written on the incentives to discard and highgrad (e.g. Anderson, 1994, Arnason, 1994, and Vestergaard, 1996 among others) but there are significant gaps in the knowledge (theoretical and empirical) regarding the economics of a landing obligation.

Incentives to discard

Depend on e.g.:

- Species composition in harvest
- Prices on fish (different sizes)
- 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



Types of constraints

Management measures defined by managers e.g.

- Quotas, effort restrictions, individual transferable quotas
- Minimum size on fish
- Mesh sizes in fishing gear

Biological e.g. species interaction and characteristics of the fish (gender, poisonous etc.)

Technological e.g. gear selectivity (prohibited gear, damages to the fish etc.)

Economical e.g. price and costs relationships determined on the market including high-grading.

The decision process

Discards occur for a number of reasons and enable some sort of planning in the fisher's decision to discard (e.g. highgrading):

- Fish < legal minimum landing size
- Fish have no or low market value
- Lack of quota
- Choke species issues

In all cases, better selectivity will reduce discards:

- Spatial aspect – area fished
- Technical aspect – gear used (incl changing gear, e.g. trawl to traps)
- Temporal aspect – time of year fished
- Market (quota) aspect – ensure catch composition matches quota

In addition, reducing fishing effort will reduce total discards but at the same time landings will decrease.

Model and practical implementation

In the "new world" with a landing obligation, landings equal catches
In the "old world" landings equal catches minus discards

Although the EU rules include exemptions, basically the premise is that unwanted catch is landed. Unwanted catches may be

- landed and sold (if quota allows),
- landed and surrendered (for e.g. fishmeal and fish oil),
- discarded at sea (under exemption), or
- illegally discarded.

This presentation includes the following topics:

- A simple theoretical model looking at
    - Impact of landing obligation under open access and optimal fishery
    - Impact of changes in technology and behaviour
- Two case studies with focus on
    - Short term economic impact of a L.O. for the Danish fleet
    - Long term impacts of a landing obligation

A simple model

Extended version of a Clark model, see Towards a Predictive Model for the Economic Regulation of Commercial Fisheries. Can. J. of Fish. and Aq. Sci., 1980, 37(7): 1111-1129.

Harvest (*h*) for vessel (*i*) is the product of a constant catchability coefficent (*q*), standardised vessel effort (*E*) and fish biomass (*x*):

$$h_i = qE_ix$$

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) as harvest contributes directly to revenue. Therefore, we assume that discards (*d*) are greater than zero.

In the simplest case for modelling discards explicitly, catchability can be defined differently for landings and discards:

$$l_i = q_lE_ix$$
$$d_i = q_dE_ix$$

The profitability of a vessel can be calculated as in Clark's model:

$$\pi_i = \pi_i(x, E_i) = pqE_ix - c_i(E_i) = (p_lq_lE_ix + p_dq_dE_ix) - c_i(E_i)$$

were price, p, is different for landed and discarded quantity.

Max profit: $MR_i = p_lq_lx + p_dq_dx = c'_i(E_i)$

Examples of questions and results under open-access

Q: Is the stock level under open access < or = or > the stock level under a discard ban?

If we assume that the cost of handling discards is proportional to the amount of discards, we can define a "discard" cost function

$$c_i^d(d_i) = c_d d_i$$

Therefore, marginal revenue (MR) can be defined as

$$MR_i = p_l q_l x + (p_d - c_d) q_d x$$

Observations:

If $p_d < c_d$ then the cost of discarding outweighs catching unwanted fish thus resulting in reduced effort, also resulting in a higher equilibrium stock level

If $p_d > c_d$ then the cost of discarding incentivises catching unwanted fish thus resulting in increased effort, also resulting in a lower equilibrium stock level.

Optimal fishery under L.O.

$$\max \sum_i^N \pi_i(x, E_i) \text{ s.t.}$$
$$F(x) = qx \sum_i^N E_i$$
$$\Rightarrow \quad (p-\lambda)qx = c_i'(E_i) = (p_l - \lambda_l)q_l x + (p_d - \lambda_d)q_d x$$

Some results:

If $p_d < c_d + \lambda_d$ then the optimal stock with a landing obligation will be larger than the optimal stock without a landing obligation.

If the stock with LO is less than the MSY stock then the optimal level of landings with a discard ban will be greater than landings without a discard ban

If the stock with LO is greater than the MSY stock then the optimal level of landings with a discard ban will be less than the optimal level of landings without a discard ban

Technology changes

Changing technology/fishing pattern and discarding: The catch of unwanted fish can be controlled through the level of technology investment and effort applied. Therefore, the catchability coefficient is a function of cost of effort,

$$q_d = q_d(c_i(E_i))$$

As the new technology improves selectivity, it follows:

$$\frac{\partial q_d}{\partial c_i} < 0$$

An example: investment in more selective fishing gear will result in less unwanted catches.

Examples of interesting questions:

1. What is the optimal investment in new technology or changes in fishing pattern for the fishers and in an optimal fishery?
2. Regarding illegal discard, what is the need to revise the classical analyses of optimal enforcement when illegal discard is included?

Important issues for empirical analyses of the impacts of a landing obligation

1. The regulatory framework
    1. Restricted open access (TAC)
    2. Gear restrictions
    3. IQ or ITQ
    4. Changes in TACs (quota top-ups/uplifts, fully or partly)
    5. Change in minimum legal size
    6. Enforcement and compliance aspects

2. Fishermen's behavior (fishing pattern, choice of gear…)

3. Net price of landed unwanted catches (previously discarded fish)

4. Stock dynamics

Case study I – Short term impacts of the landing obligation (Andersen and Ståhl, 2016)

The purpose of the study is to estimate the short term economic impacts for the Danish fleet of the EU landing obligation (L.O.)

- under various assumptions about:

- Quota top-ups (uplifts)
- Increased quota utilisation
- Changes in legal minimum sizes for human consumption
- Changes in discard fractions (more selective gear)

What is analysed in the Danish study?

1. **Short term economic impacts for the whole Danish fleet and fleet segments:** Impact on an average vessel in fleet segments – calculated as changes in revenue and gross margin profit in nine different scenarios:
    - Baseline: The fishery in 2013
    - Corresponding quota adjustment/top-up or no quota adjustment/top-up
    - Increased quota utilisation
  - Changes in legal minimum sizes
  - Behavioural change: Reduction in discard fraction

2. Other effects

  - Assessment of effects on downstream industry (input/output model)
    - Assessment of longer term effects (no empirical analysis)

3. We did <u>not</u> look into the impacts of

    - Stock effects
    - Technology changes
    - Complex behavioural changes
    - Discard in pelagic and industrial fisheries
    - Imperfect control and enforcement (a very important topic)
  - The problem of ”choke species” (a very important topic)

Methodological approach I

Framework

- Catch data and economic data from 2013
- Only commercial vessels and demersal species and no specialised fisheries (e.g. mussels)
- Not enough data to cover pelagic species
- Only quota species are directly included in analysis
- Changes in catches of non-quota species (”bycatch”) included indirectly if vessels reduce effort (proportion principle)

Outcome

- Analysis and results by 19 fleet segments based on vessel length and gear
- Results also presented for North Sea fleet, Baltic Sea fleet, Skagerrak/Kattegat fleet, and the whole Danish fleet

Methodological approach II

Economic impact of the landing obligation for each of the 19 fleet segments is calculated as the difference in the various scenarios from the baseline situation in 2013:

Revenue: Landings value

Variable costs: Fuel, ice, supplies, landings and sales costs (average costs)

Profitability: Landings value minus variable costs (excl. wages and capital costs)

Wages: Assumed to be in proportion to landed value

Gross margin: Landings value minus variable costs and wages

Methodological approach III

Assumptions

- Variable costs change in proportion to effort change
- No changes in fishering patterns
- Catches of non-quota species in proportion to reduction in effort
- No price effects from changes in landed volumes

Methodological approach IV

Marketable landings (ML) in scenarios without quota top-up:

$$ML^{N} = L^{O} * (1 - dp)$$

Marketable landings (ML) in scenarios with quota top-up:

$$ML^{N,Q} = L^{O}$$

where

L^{N}: Marketable landings **N**ew (after L.O.),

$L^{N,U}$: Marketable landings **N**ew (after L.O.) with quota top-up,

L^{O} : Marketable landings **O**ld (before L.O.),

dp: Discard percentage

Scenario	Description	Explanation
0 scenario	Basis scenario: The Danish fishery in 2013 is used as basis for comparison	2013 situation with discard for different segments and fishing areas
Scenario A1	2013 situation without quota uplift and therefore a reduction of landings and effort **(Effort reduction)**	Reduction of catch value, the landings of previously discarded fish replace some of the wanted catch. Effort reduction (reduction in variable costs) in proportion to the reduction in catch
Scenario A2	As scenario A1 and additional costs of handling former discard onboard **(A1 + handling costs)**	Increased variable costs caused by costs of handling a more mixed catch. This can be viewed as a ”Worst Case Scenario”
Scenario A3	No quota uplift and therefore an effort reduction but a part of landed discard can now be sold for consumption **(A1 + new minimum sizes)**	2013 situation, no quota uplift, but where the part of landed discard which was previously between the old and new minimum sizes will be sold for consumption (lowest price class)
Scenario A4	No quota uplift and therefore effort reduction, but with improved quota utilization (≤ TAC). **(A1 + improved quota utilization)**	2013 situation, no quota uplift, but the quota utilization increases when the previously discarded fish is included in the quota
Scenario B1	2013 situation with quota uplift and no reduction in effort **(Quota uplift)**	Landings = Previous landings + Estimated landed discard
Scenario B2	Quota uplift no effort changes but additional costs of handling former discard onboard **(B1 + handling costs)**	Increased variable costs caused by costs of handling a more mixed catch.
Scenario B3	Quota uplift and a part of former discard can now be sold for consumption purposes **(B1 + new minimum sizes)**	2013 situation, with quota uplift, but where the part of former discard which was previously between the old and new minimum sizes can be sold for consumption purposes (lowest price class)
Scenario C1	2013 situation with behavioral changes **(A1+behavioral changes)**	C1 is like A1, but a change in behavior is assumed which reduces unwanted catches (former discard) by 25 %
Scenario C2	2013 situation, with quota uplift and behavioral changes **(B1+ behavioral changes)**	C2 is like B1, but a change in behavior is assumed which reduces unwanted catches (former discard) by 25 % (C2 is only calculated for the total fishery)

Results – changes for the entire Danish fleet compared to 2013 baseline

	DKK 1000[1] or %				ton	
	changes in					
Scenarios	**Revenue**	**Gross Margin**	**Revenue**	**Gross Margin**	**Discard landings[2]**	**Marketable landings**
A1: Effort reduction (no quota adjustment)	-168,815	-127,792	-7%	-9%	-3,896	-8,541
A2: A1 + handling costs	-168,815	-147,554	-7%	-10%	-3,896	-8,541
A3: A1 + new minimum sizes	-92,719	-65,272	-4%	-4%	-5,891	-6,328
A4: A1 + increased quota utilisation	-69,356	-58,270	-3%	-4%	-1,689	-2,469
B1: Corresponding quota adjustment	10,769	8,435	0.4%	0.6%	0	0
B2: B1 + handling costs	10,769	-20,490	0.4%	-1%	0	0
B3: B1 + new minimum sizes	73,349	64,997	3%	4%	-4,084	6,685
C1: A1 + behavioural changes (25 % less discard landings)	-126,613	-95,845	-5%	-7%	-5,614	-6,406
C2: B1 + behavioural changes (25 % less discard landings)	6,822	5,209	0.3%	0.4%	-3,947	0

1) €1 = DKK 7,5; 2) Discard landings = Discard before L.O. – Discard landings with L.O.

Results – changes for trawl 18-24 m - compared to 2013 baseline

	DKK 1000 [1] or %				*ton*	
	changes in					
Scenarios	**Revenue**	**Gross margin**	**Revenue**	**Gross margin**	**Discard landings[2]**	**Marketable landings**
A1: Effort reduction (no quota adjustment)	-39,307	-32,181	-17%	-29%	-816	-1,793
A2: A1 + handling costs	-39,307	-34,977	-17%	-32%	-816	-1,793
A3: A1 + new minimum sizes	-20,754	-17,151	-9%	-15%	-1,311	-1,298
A4: A1 + increased quota utilisation	-16,555	-13,957	-7%	-13%	-399	-711
B1: Corresponding quota adjustment	2,230	1,901	1%	2%	0	0
B2: B1 + handling costs	2,230	-2,547	1%	-2%	0	0
B3: B1 + new minimum sizes	18,417	16,393	8%	15%	-967	1,262
C1: A1 + behavioural changes (25 % less discard landings)	-29,410	-24,066	-13%	-22%	-1,169	-1,184
C2: B1 + behavioural changes (25 % less discard landings)	1,428	1,200	1%	1%	-802	0

1) €1 = DKK 7,5; 2) Discard landings = Discard before L.O. – Discard landings with L.O.

Main findings

- Negative economic impacts when no quota top-up (especially if substantial discards for important species).
  - a reduction of the legal minimum sizes would reduce losses.
  - increased quota utilisation would also reduce losses.

- Largest economic impact on Baltic Sea and Kattegat/Skagerrak fisheries
- Less impact on the North Sea fisheries.

- Largest impact on small and medium sized trawlers
- decrease in revenue by on average 20%
- decrease in gross margin by 30%-50%

- Species contributing to a large degree to the changes in revenue and gross margin are the Nephrops fishery (Norwegian lobster fishery) in Kattegat as well as cod and plaice in the Baltic Sea and Skagerrak.

- Quota top-ups are crucial to avoid significant negative economic impacts and under certain assumptions result in economics gains.

Examples of partial results

➢ ***Where is the landing obligation felt the most?***

- The fleet subgroups with the **largest decrease** (sc. A1) in revenue and gross margin respectively are the trawlers:

  Revenue decrease: between 17% and 28%
  Gross margin decrease: between 27% and 48%

- Mostly explained by the high discard of Nephrops (Norwegian lobster) in Kattegat/Skagerrak as well as cod in the Baltic Sea and Skagerrak.
- New minimum sizes/increased quota utilisation can reduce the financial losses considerably (>50%).
- Quota top-ups corresponding to "previous discard" could be beneficial especially in combination with new minimum sizes.

Case study II – Medium and long term impacts of the landing obligation (Hans Frost & Ayoe Hoff, 2017)

The main purpose of the study is to analyse the long term economic impacts for the whole Danish fleet of the EU landing obligation

Static comparative model under various assumptions:

- Quota top-ups
- Landing costs
- Changes in legal minimum sizes for human consumption

What is analysed in the long term study?

1. **Long term economic impacts for the whole Danish fleet:**

   Impact on fleet – calculated as changes in revenue and gross margin profit different scenarios:

   - Baseline: The fishery in 2012-2014
   - Corresponding quota top-up or no top-up
   - Changes in legal minimum sizes
   - Additional handling costs of previously discarded fish

3. Did not look into the impacts of

- Technology changes
- Imperfect control and enforcement (a very important topic)
- Effects on downstream industry

Methodological approach

Data and framework

- Catch data and economic data from 2012-2014, averages, monthly level
- Quota data from 2015
- Only commercial vessels and no specialised fisheries (e.g. mussels)
- The 12 most important species L.O. species included in analysis, 20 species in total
- Changes in catches of non-quota species (”bycatch”) included indirectly if vessels reduce effort (proportion principle)

Outcome

- Analysis and results for the overall Danish fleet (covering 411 vessels)
- Changes in revenue, costs, profitability, as well as quantities of fish above and below minimum sizes are reported for each scenario
- Quota top ups defined as in the short-term analysis

Methodological approach III

Model setup

Non-linear programming model

Static comparative

Analysis

1)

Baseline: The fishery in 2015 (avg. 2012-2014)

Baseline of present, non-optimised, ITQ system

2)

Medium term baseline: Days at sea change to maximise gross margin

Long term baseline: Days at sea as well as number of vessels change to maximise gross margin

→ Baselines in the optimised ITQ system

3)

Economic impacts in scenarios in the medium and long term are measured against the medium and long term baseline respectively

→ Isolated effect of L.O.

Methodological approach II

Assumptions

- Variable costs change in proportion to effort change
- Fixed costs do not change in the medium term but change in the long term
- Catches of non-quota species in proportion to reduction in effort
- No price effects from changes in landed volumes

Scenario	Description	Explanation
K0	Basis short term: the Danish fishery in 2015	2015 situation where the LO is not implemented. Quotas are those for 2015, while days-at-sea, catch per unit of effort and landing patterns are based on averages for 2012-2014
ML0 **Basis – no L.O.**	Basis medium term: the Danish fishery in 2015 optimized with regards to days-at-sea	As K0, but where it is asked how the economic situation in 2015 could have been if days-at-sea were distributed in an economically optimal way between fleet segments, months and fishing areas The number of vessels are kept constant
L0 **Basis – no L.O.**	Basis long term: the Danish fishery in 2015 optimized with regards to days-at-sea and number of vessels	As ML0, but where the number of vessels are adjusted to the optimal number
Landing obligation is implemented. The price obtained for fish previously discarded is DKK 1.5/kg		
ML1: **L.O., fishmeal price**	Landing obligation – Medium term	As ML0, but where landing costs for previously discarded fish is DKK 0 and sales price for these fish is DKK 1,5/kg
L1: **L.O., fishmeal price**	Landing obligation – Long term	As ML1, but where the number of vessels in each segment is adjusted so that the economic performance of the total fleet is maximized
ML3: ML1+ **high handling costs**	Handling costs – Medium term	As ML1 but with a landing cost of DKK 2.5/kg for fish below the reference size
L3: L1+ **high handling costs**	Handling costs – Long term	As ML3, but where the number of vessels is adjusted to maximize the economic performance of the total fleet
ML4: ML1+ **new minimum sizes**	New minimum sizes – Medium term	As ML1, but where the quantity of previously discarded fish that is now between the old and the new minimum size can be sold for human consumption
L4: L1+ **new minimum sizes**	New minimum sizes – Long term	As L1, but where the quantity of previously discarded fish that is now between the old and the new minimum size can be sold for human consumption

Results I – without quota top-ups

Key figures for medium-term scenarios

	Basis, no LO (ML0)	L.O., fishmeal price (ML1)	L.O., ML1+high handling costs (ML3)	L.O., ML1+new minimum sizes (ML4)
	Bill. DKK[1] (%)			
Total revenue	4.0	3.7 (-5.4)	3.7 (-6.8)	3.8 (-3.1)
Gross margin	2.0	1.9 (-2.9)	1.9 (-3.9)	2.0 (-0.1)
Marketable landings (1000 t)	903.2	893.9 (-1.0)	890.3 (-1.4)	889.6 (-1.5)
Discard landings (1000 t)	23.0	13.0 (-43.7)	12.4 (-46.1)	13.0 (-43.6)
Effort/ Days at sea (1000)	74.6	65.8 (-11.8)	64.5 (-13.5)	64.9 (-13.1)

Key figures for long-term scenarios

	Basis, no LO (L0)	L.O., fishmeal price (L1)	L.O., L1+handling costs (L3)	L.O., L1+new minimum sizes (L4)
	Bill. DKK[1] (%)			
Total revenue	4.1	3.8 (-6.1)	3.8 (-7.2)	3.9 (-3.6)
Gross margin	2.1	2.0 (-3.6)	2.0 (-4.6)	2.1 (-0.1)
Marketable landings (1000 t)	1019.1	989.8 (-2.9)	988.9 (-3.0)	987.4 (-3.1)
Discard landings (1000 t)	23.9	12.3 (-48.4)	11.9 (-50.3)	12.4 (-48.4)
Effort/ Days at sea (1000)	73.9	64.6 (-12.6)	63.9 (-13.5)	63.5 (-14.0)

Note: Numbers in parenthesis are percentage changes in relation to L0. Gross margin = Revenue – Wages – Variable costs.

[1]€1 = DKK 7.5

Results II – with quota top-ups

Key figures for medium-term scenarios

	Basis, no LO (ML0)	L.O., fishmeal price (ML1)	L.O., ML1+handling costs (ML3)	L.O., ML1+new minimum sizes (ML4)
		Bill. DKK[1] (%)		
Total revenue	4.0	4.1 (2.5)	4.0 (0.7)	4.3 (7.6)
Gross margin	2.0	2.0 (1.5)	2.0 (0.2)	2.1 (7.0)
Marketable landings (1000 t)	903.3	905.4 (0.2)	902.7 (-0.1)	902.5 (-0.1)
Discard landings (1000 t)	23.0	18.7 (-18.8)	17.9 (-22.1)	18.7 (-19.0)
Effort/ Days at sea (1000)	74.6	78.0 (4.6)	77.1 (3.4)	76.2 (2.1)

Key figures for long-term scenarios

	Basis, no LO (L0)	L.O., fishmeal price (L1)	L.O., L1+handling costs (L3)	L.O., L1+new minimum sizes (L4)
		Bill. DKK[1] (%)		
Total revenue	4.1	4.2 (2.7)	4.1 (1.4)	4.4 (7.4)
Gross margin	2.1	2.1 (1.7)	2.1 (0.5)	2.2 (7.3)
Marketable landings (1000 t)	1019.1	1025.3 (0.6)	1024.4 (0.5)	1016.0 (-0.3)
Discard landings (1000 t)	24.0	17.8 (-25.7)	17.3 (-27.6)	17.5 (-26.8)
Effort/ Days at sea (1000)	73.9	76.8 (3.9)	76.6 (3.7)	75.3 (1.9)

Note: Numbers in parenthesis are percentage changes in relation to L0. Gross margin = Revenue – Wages – Variable costs.

[1]€1 = DKK 7.5

Main findings

Quota top ups necessary to ensure economic profitability

Lowering the size limits while topping up quotas gives the largest increase in gross margins

Second largest increase in gross margins when previously discarded fish can be sold at fishmeal prices

Additional handling costs for previously discarded fish causes the smallest increase in gross margins

- and largest losses without quota top-ups

Lowering the legal minimum size limits of fish for consumption when quotas are not topped up reduces economic losses the most (close to no impact of L.O.)

Conclusions and discussion

A fishery management system with landing obligation:

- demands an extended version of the "standard" fisheries economic models

- empirical analyses of the impact of a L.O. based fisheries management system become more complicated

- economic advice regarding an efficient management system will increase focus on the incentives to fish more selectively and on the enforcement aspect

- The landing obligation will also have environmental impacts as birds, seals, and other ecosystem services will be affected when discards are reduced significantly

Conclusions and discussion

If the landing obligation is rigorously introduced

- fishers will be restricted by choke species as the catch composition most likely will not fit the relative quotas between different species very well

- the choke problem will differ across fleet segments if the allocation system is sticky or the ITQ system is restricted

- for these reasons the EU Common Fishery Policy with the relative quota stability as a core element will be put under severe pressure as only some of the EU member states use an ITQ system and there is no general quota trading system across member states in place

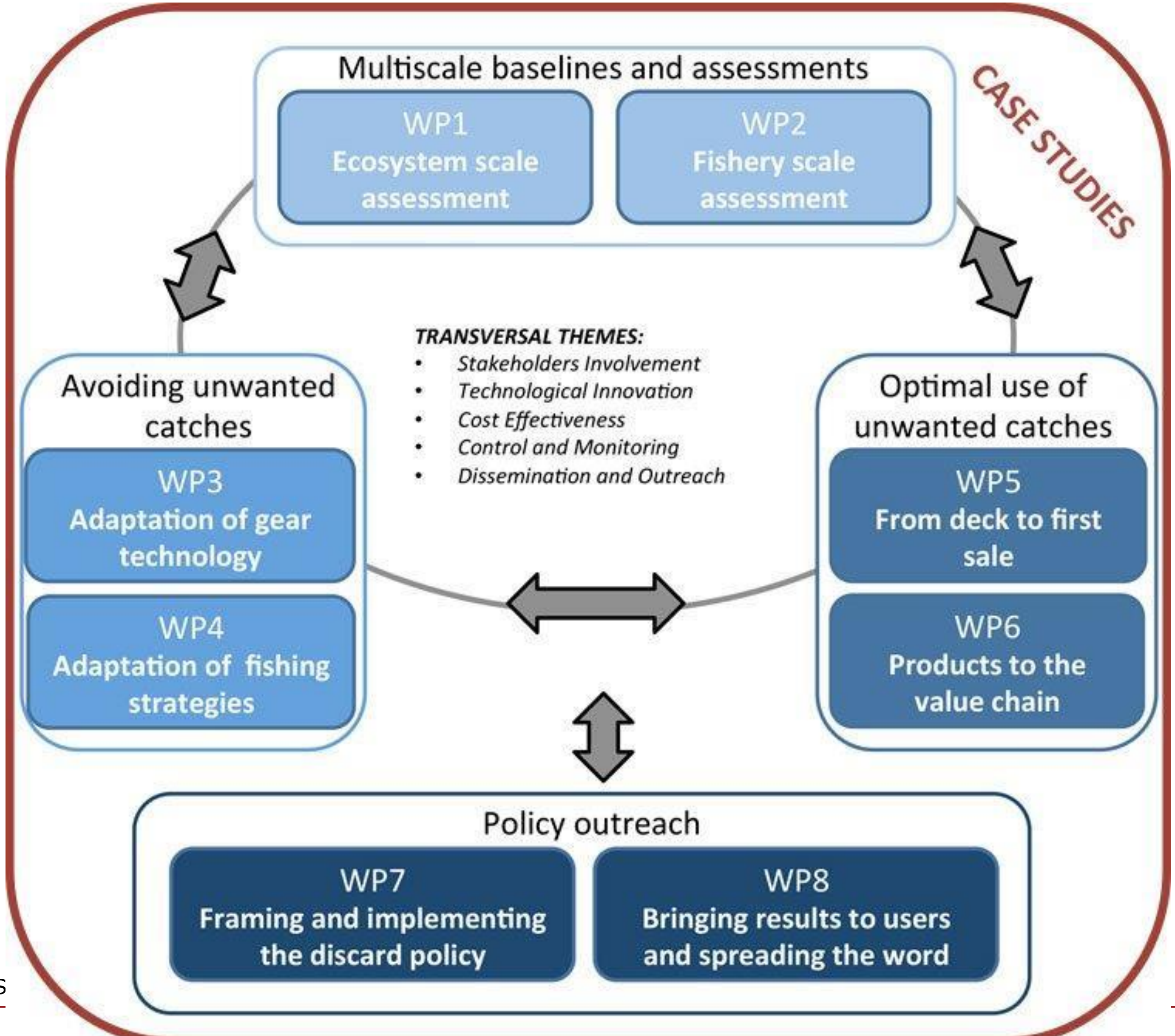
Conclusions and discussion

Future work:

- need for better models and data to improve economic analyses of a landing obligation
- empirical analyses should include behavioral change with regard to selectivity, substitution, economic viability of fleets, learning across fleets and fisheries, and investment decisions and disinvestment regarding selective fishing gear

Future work on the landing obligation is part of the EU project Discardless (www.discardless.eu) with focus on impacts of stock effects, technology changes and selectivity, complex behavioral changes as well as imperfect control and enforcement of the landing obligation.

Structure of the project "Discardless"



Discardless

DiscardLess is designed to take on the simultaneous challenges and opportunities of studying and implementing a radical new management approach - the landing obligation. Placing DiscardLess in its policy context will bring it to the forefront of documenting the history of a fundamental paradigm shift in European fisheries management.

Significant progress beyond the state-of-the-art will be achieved in all eight WPs, while it is recognized that the science base on discarding will continue to expand rapidly.

WP2 will play a central role in filling knowledge gaps and monitoring actual changes in economic profitability and in stakeholders' attitudes and perceptions. Since incentives to discard usually do not coincide with society's management goals, analyses are needed both on the socio-economic as well on the business economic level.

Lead: Department of Food and Resource Economics, University of Copenhagen, Denmark