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Jobs lost at sea

Overfishing and the jobs that never were

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Photo: Aniol Esteban

Fish stocks deliver huge benefits to society. They are a source of jobs, a source of profits, and a source of affordable food. But European fish stocks are delivering much less than they could if they were managed at sustainable levels. For the good of society, restoring fish stocks from current levels to their maximum sustainable yield should be at the heart of European fisheries management. The reform of the Common Fisheries Policy is an ideal opportunity to put an end to this waste.

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The problem

Overfishing is said to occur when fish are captured at a faster rate than they reproduce. This phenomenon has plagued European waters for decades, but has only recently come under public scrutiny. The enormously wasteful practice of discarding fish, throwing away up to 20 to 98 per cent of catch in European fisheries, has sparked public outrage.[1,2,3] Yet this is but one part of a worrying trend in the marine world. Some fish stocks have been fished to the brink of collapse. Some catches are but a shadow of their former selves. The decline in catches has been mirrored by corresponding falls in fishing revenues and, in some countries, the numbers of jobs they support.[4] But for many, struggling in the midst of a global economic crisis, this catastrophe is both out of sight and out of mind.

Yet, it is precisely in times such as these that natural resources should be better managed to produce more revenue and jobs. In this paper, we study 43 fish stocks in European and neighbouring waters and look at how healthy fisheries could sustainably provide more catches and what this means in terms of additional revenue and jobs. We find that over €3 billion is lost every year due to overfishing these stocks. This could support 100,000 jobs in the industry and inject money into a bleeding economy. Isn't it time we rebuilt our fish stocks?

What it means

Overfishing is the single greatest destructive force in the marine environment.[5] It has made the fishing industry economically vulnerable and caused coastal communities to crumble; instead of rebuilding stocks, the industry has become heavily subsidised by the taxpayer.[6,7,8] This is a losing battle; in just these sample stocks, the cost of overfishing is five times the value of EU subsidies.[9]

Each fish stock has a maximum sustainable yield (MSY; the largest catches that can be sustained over the long-term) which is balanced by the maximum replenishment rate of a healthy fish stock. With relatively few exceptions, annual catches have risen above this level, such that the stock size has decreased. And, with a smaller stock, only smaller catches can be sustained the following year. The net result is the tragic loss of human livelihoods[10] and natural[11,12] resources, our most precious commodities. Rebuilding fish stocks may return revenue and job levels to the maximum supported, but the loss of productivity during the years they were overfished and the time it takes to rebuild them can never be regained. And, in some cases, the stocks never recover.

Data on long-term employment in the fishing industry is difficult to find at the EU level and particularly at the member state level. Two sources covering a similar period show different results. One source finds that in the 1996–1998 period there were around 258,000 fishermen in the EU, falling to around 209,000 by 2002/2003.[13] Another finds a variable level of between 112,000 and 189,000 fishermen over the 2002–2009 period.[14] The impact of falling revenues on employment in the EU27 over the last twenty years has been partly offset by subsidies. On the other hand, the global economic crisis has led to a surge in unemployment across most sectors.

What to do about it

The solution, like the problem, is well understood by biologists and economists: catch fewer fish than the stock's regeneration rate. Many examples of successful fisheries management now exist worldwide, but sadly not enough exist in Europe.

When fish stocks begin the downward slide towards collapse, fishing should be stopped. In New Zealand, Australia, and the United States, legislation encourages precautionary fishing limits and closures are enforced, helping to reverse the decline.

In Europe, however, where 72 per cent of commercial fish stocks are below optimal level, *gradual* reductions in fishing pressure as a stock begins to collapse – the proposed reform to the Common Fisheries Policy (CFP) – are unlikely to reverse this trend.[15]

Photo: © OCEAN2012 and Corey Arnold

Even with the current levels of overfishing, some EU member states resist setting MSY levels as a target for fisheries management. In the period 1987–2011, European fisheries ministers set fishing quotas above scientific recommendations in 68 per cent of decisions.[16] In the case of one hake stock, quotas were set 1,100 per cent higher than advised.[17] By delaying the rebuilding of stocks, fishing countries are foregoing catches, revenue, and jobs and yet many continue to manage their fisheries to the detriment of the environment in order to 'satisfy short-term economic or political objectives'.[18]

The reform of the CFP is an ideal opportunity to put an end to this waste. Catch limits need to be set at a level that ensures the rapid recovery of fish stocks to MSY levels ('B_{MSY}') and a healthy marine environment.[19] Public resources – fish quotas and subsidies – need to be allocated to those who fish sustainably and to activities that will put our fish stocks in better shape.[20] Unfortunately, it is the public owners of the fish who stand to gain or lose the most from these reforms, and yet their voice is the quietest of all.

Fishing for the future

To illustrate the potential benefits of restoring European fish stocks, we compare current landings from 43 fish stocks with landings that could be delivered were stocks restored to their most productive level.

The 43 fish stocks cover European and neighbouring waters. Some of these stocks are fished sustainably, albeit far below their potential (i.e. they are in an overfished state but not declining). Others are being unsustainably overfished and their landings are higher than their sustainable maximum. One haddock stock,* for instance, is currently being fished twice as much as its sustainable maximum. Of the 43 stocks studied, only three are being fished close to their sustainable maximum: saithe in the North-East Arctic,[21] sole in the Eastern English Channel,[22] and Norwegian spring-spawning herring.[23]

Across all stocks studied, we found that:

1. Catches in 2010 amounted to less than 64 per cent of their maximum potential weight (9.76 million tonnes) and 55 per cent of their potential value.

2. Restoring these 43 stocks to their MSY level would generate 3.53 million tonnes of additional landings; enough to meet the annual demand of fish for 155 million EU citizens.[24]

3. These additional landings would be worth €3.188 billion annually, which is more than five times the annual fisheries subsidies paid to EU member states.[25]

4. This additional value could support the equivalent of 32,000 full-time fishing jobs, and 69,000 (full- and part-time) processing jobs every year. Just under 83,000 of these are in the EU27.

Tables 1–3 summarise our results.

We have calculated the value of potential additional landings using a region-specific price per species at the first point of sale and have adjusted for inflation (value is in 2010 real terms). The UN and World Bank have estimated the global cost of overfishing at US$50 billion/year; the results of our analysis suggest that around 8 per cent of this cost occurs in the North Atlantic.[28] The benefits of rebuilding these stocks would accrue to all countries currently fishing them, but most of all to the EU27 where we estimate its landings values could more than double from these stocks alone. Some stocks have even more room for improvement: landings (by weight) from North Sea cod and haddock could be 5.4 and 6.5 times larger than they are now.

In estimating employment figures, we have looked at employment rates for each region, based on current landing revenues. The 100,000 figure refers to potential additional jobs that could be supported across all countries with the additional revenue from rebuilding these 43 stocks. This figure also accounts for inflation and country-specific employment rates (with a few exceptions for non-EEA countries, such as Russia).

* North-East Arctic haddock (Sub-areas I and II)

Table 1. Additional landings from restoring 43 European stocks to MSY levels.

Landings at MSY (tonnes)	*2010 landings (tonnes)*	*Potential additional catch (tonnes)*
9,756,519	6,230,564	3,525,955

Source: own calculations (see technical appendix).

Table 2. Value of additional landings (€ million).

Landings at MSY (€m)	*2010 landings (€m)*	*Potential additional value (€m)*
7,137	3,949	3,188

These values accrue largely to Europe (97.3 to 99.9 per cent).*Source*: own calculations (see technical appendix).

Table 3. Jobs that these revenues could support.

Fishing	*Processing*	*Total*
31,802	68,988	100,790

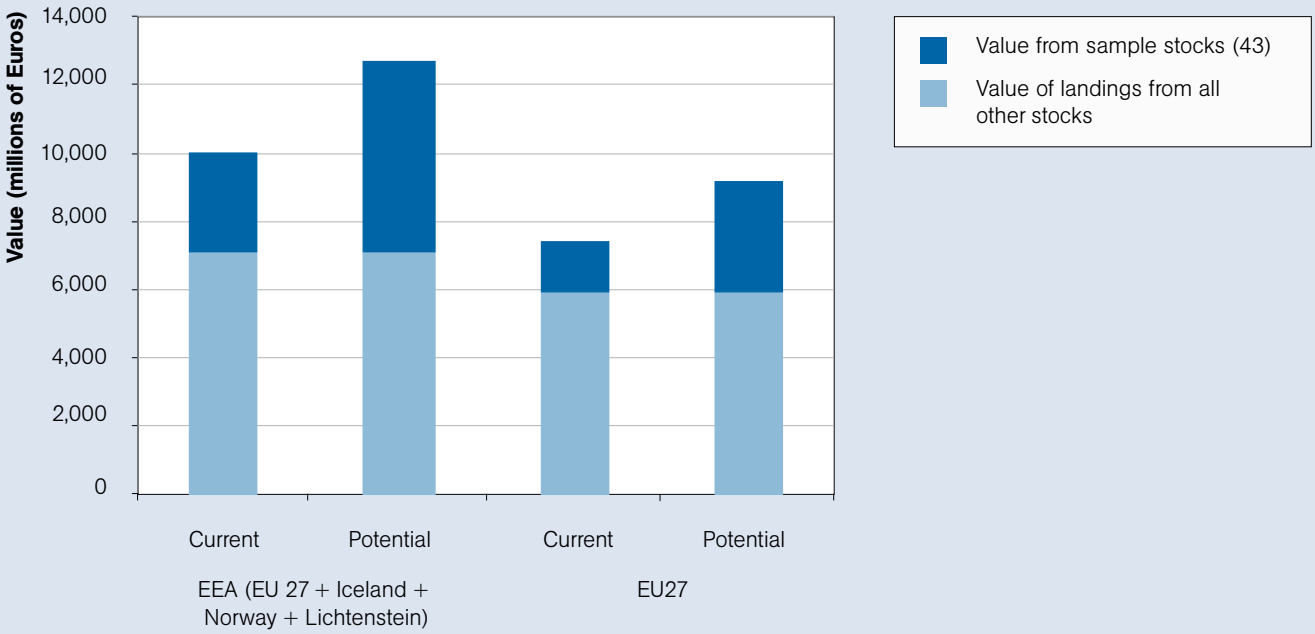
Again, most of these jobs (97.3 to 99.9 per cent) are based in Europe, particularly the EU27, Norway, Iceland, Russia, Greenland, and the Faroe Islands. *Source:* own calculations (see technical appendix).

Table 4. Comparing potential additional benefits to current subsidies.

	Annual fisheries subsidies to EU27 (€m)	*Annual benefits from rebuilding 43 stocks (all regions) (€m)*	*Value multiplier of rebuilding stocks compared to subsidies*
2007-2013 (European Fisheries Fund)	615	3,188 (1,820 to EU27)	5.18 (2.96 to EU27)
2014-2020 (European Maritime Fisheries Fund)	929	3,188 (1,820 to EU27)	3.43 (1.96 to EU27)

Average annual subsidies (EFF and EMFF) compared to the value of rebuilding stocks. For the EU27 total, the benefits of just having these 43 stocks at MSY dwarf the annual fisheries subsidies. Average annual subsidies are estimated by dividing total European Fisheries Fund amount for 2007–2013 (€4.3bn) and planned European Maritime and Fisheries Fund for 2014–2020 (€6.5bn) by the 7-year time period. *Source:* EFF Fact Sheet and own calculations (see technical appendix).[26,27]

Figure 1. Value of rebuilding stocks relative to current landings of the 43 sample stocks and landings from all other stocks. Rebuilding the 43 sample stocks adds more value than the EU27 currently gets from fishing them.



Our results underestimate the potential gains of restoring European fish stocks because our analysis only covers 43 fish stocks out of over 150 fish stocks. Their distribution is mostly in the North Atlantic seas, and none are in the Mediterranean. Europe also suffers from overfishing in other stocks, most notably those in the Mediterranean where total landings by EU fisheries have declined by 30 per cent over the past decade.[29] These are not included here due to lack of available data.

In the majority of cases where landings have declined because of smaller fish stocks, landings are considerably lower than their maximum potential. For all the years that fish stocks have been mismanaged, fishermen, their communities, and the economy suffer. Rebuilding fish stocks will not bring back the revenue and jobs lost over the intervening years, but it will put an end to this drain on resources and place the fishing industry on firmer ground. Every year that fish stocks are below MSY, 100,000 jobs sink below sea level.

Technical appendix

Methodological Summary

The basis for our calculations is the estimates of Maximum Sustainable Yield (MSY) for 43 fish stocks. Landings data is used to find current landings from these stocks. The amount lost from the stocks – and their restoration potential – is simply the difference between current landings and MSY. The value of this loss in monetary terms requires another step of calculation to convert the lost tonnes into corresponding lost revenue. We use a price per tonne of fish, found at a species and region-specific level by dividing the weight of landings by its value. This leads to estimates of a price per tonne of landed fish of each species, per region. By multiplying this by the tonnes lost from overfishing, we estimated total lost revenues per stock. These figures are then converted to Euros and adjusted for inflation; the final values are presented in Euros and GBP (after also converting Euros to GBP). Lost revenues are then apportioned to each fishing country based on their current share of landing values from each region. Employment was then estimated based on jobs currently supported by landing revenues in each country involved. To do this, full-time equivalent (FTE) fishermen jobs and full-time and part-time processing jobs in each country were divided by the landing values made in those countries and which support those jobs. Other income streams, such as subsidies, are excluded, though doing so inherently implies their role in supporting jobs scales proportionately with landing values. Then, by multiplying the lost revenues, per country, by the jobs supported per unit of landings revenue, we estimate the number of jobs lost at sea through overfishing.

Materials

Our data sources are listed in Table A1.

Questions & Answers on Methods

Where do the MSY estimates come from? Are they reliable?

The MSY estimates are taken from a paper by Froese and Proelß,[30] which estimates individually the MSY for 54 different stocks. We used 43 of these for which we could obtain the sufficient economic data (see Table A2).[31] The estimates we used are an average of the midpoint estimates from the three different methods for estimating each stock's MSY.[32] In using multiple methods, the MSY estimates could be considered more thoroughly researched than in many other papers. However, not all stocks could employ all methods because of data deficiency, and the confidence intervals tend to be large. More importantly, we believe, is the weakness in trying to return all stocks to MSY level. Evidently, a prey species cannot be at its own individual MSY if its predator species is also at MSY. Ideally, these ecosystem dynamics would be included so that a multi-species MSY could be estimated. This demand is beyond the current literature. The consequence for our estimates is that the loss is likely to be overestimated, though by an unknown degree.

Without even considering ecosystem feedback effects, estimating MSY is fraught with difficulties. Even fisheries scientists advising governments are reluctant to estimate fish stocks' potential because the data used for such studies depends on decades of misleading information – we simply do not know what their potential is because, in short, fishing has already altered the benchmark for potential fish stock size, either through decreasing its size or altering its ecosystem. An example of this is the 'shifting baseline syndrome' described by Daniel Pauly.[33] The approach taken by many fisheries scientists is, therefore, necessarily and justifiably cautious, and similar caution should be applied to the MSY estimates. At the same time, these estimates use very widely employed methods, very similarly to studies such as the World Bank/United Nations' *Sunken Billions* report.[34]

Table A1. Summary of materials: Data types, uses, notes, sources and links used in this study. NEI: Not elsewhere included, LME: Large Marine Ecosystem.

Data	Use	Notes	Source	Link
MSY estimates for 43 stocks	Estimates of the maximum potential of the stocks (tonnes)	43 stocks, unit: tonnes, time independent	Froese, R. & Proelß, A. (2010) Rebuilding fish stocks no later than 2015: will Europe meet the deadline? Fish and Fisheries, 11(2), 194–202. Supporting information. DOI: 10.1111/j.1467-2979.2009.00349.x	http://onlinelibrary.wiley.com/doi/10.1111/j.1467-2979.2009.00349.x/abstract
Landing weights for 43 stocks in 2010	Current catch sizes (tonnes)	43 stocks, unit: tonnes	International Council for the Exploration of the Sea (ICES)	http://www.ices.dk/indexfla.asp
Landing values for multiple species in LME's (2002-2006)	Calculating a price per tonne per species per region (2002-2006)	43 stocks, distributed over multiple LME's, unit: real 2000 value (US$)	Sea Around Us Project, University of British Columbia Fisheries Centre	http://www.seaaroundus.org/
Landing weights for corresponding multiple species in LME's (2002-2006)	Calculating a price per tonne per species per region (2002-2006)	43 stocks, distributed over multiple LME's, unit: tonnes	Sea Around Us Project, University of British Columbia Fisheries Centre	http://www.seaaroundus.org/
Average annualised inflation rate (US$)	Used to adjust all real 2000 US$ values to their nominal US$ values		The Federal Reserve Bank of Minneapolis	http://www.minneapolisfed.org/community_education/teacher/calc/hist1800.cfm
Average annualised exchange rate (US$ to Euro)	Converting nominal values in any year 2002-2006 to 2002-2006 Euros		United States Board of Governors of the Federal Reserve System (US Federal Reserve)	http://www.federalreserve.gov/datadownload/
Average annualised fish-specific inflation rate (Euro)	Used to adjust all nominal 2002-2006 Euro values to 2010 real Euro values	Once all years were calculated in 2010 real terms, averages were taken of the 5 years	European Central Bank (ECB)	http://www.ecb.int/stats/prices/hicp/html/index.en.html
Average annualised exchange rate (Euro to GBP)	Conversion of 2010 Euros to GBP£	Exchange rate: £1 : 1.1664 Euro	Bank of England (BoE)	http://www.bankofengland.co.uk/mfsd/iadb/Index.asp?first=yes&SectionRequired=I&HideNums=-1&ExtraInfo=true&Travel=Nix
Processing jobs multiplier	Used to estimate the number of processing jobs per FTE fishing job	Available data does not distinguish FTE and part-time employment in processing; we expect a substantial proportion of processing jobs to be part-time. No units	Facts and figures on the Common Fisheries Policy (2010). Basic Statistical Data. European Commission Maritime Affairs and Fisheries. ISSN 1830-9119. Luxembourg: Publications Office of the European Union, 2010. doi:10.2771/12708.	http://ec.europa.eu/fisheries/cfp/index_en.htm
Jobs per million Euros (per country)	Number of jobs supported per million 2010 real term euros landed (2002-2010), which is used to estimate total jobs lost	Calculated over 2002-2010. Units: jobs per million Euros landed	EU27, NEI: Anderson, J., Guillen, J. & Virtanen, J. (2011). The 2011 Annual Economic Report on the EU Fishing Fleet (STECF-11-16). European Commission Joint Research Centre. Final EUR 25106 EN - 2011. Luxembourg: European Communities.	https://stecf.jrc.ec.europa.eu/reports/economic?p_p_id=20&p_p_lifecycle=0&p_p_state=maximized&p_p_col_id=column-2&p_p_col_count=1&_20_struts_action=%2Fdocument_library%2Fview&_20_folderId=256769
			Norway & Russia: Statistics Norway	http://statbank.ssb.no//statistikkbanken/default_fr.asp?PLanguage=1
			Iceland, Greenland and Faroe Islands: Statistics Iceland	http://www.statice.is/Statistics/Wages,-income-and-labour-market

Table A2: The 43 stocks analysed in this paper and their distribution across Large Marine Ecosystems (LME's).

Stock	*Stock ID*	*Large Marine Ecosystem (LME)*
North-East Arctic cod (Sub-areas I and II)	cod-arct	Barents Sea and Norwegian Sea
North-East Arctic haddock (Sub-areas I and II)	had-arct	Barents Sea and Norwegian Sea
North-East Arctic saithe (Sub-areas I and II)	sai-arct	Barents Sea and Norwegian Sea
Herring in Sub-divisions 22-24 and Division IIIa (spring-spawners)	her-3a22	Baltic Sea
Herring in Sub-area IV, Divisions VIId & IIIa (autumn-spawners)	her-47d3	North Sea
Herring in Division VIa (North)	her-vian	Celtic-Biscay Shelf
Capelin, Iceland-East Greenland-Jan Mayen Area(V XIV IIa west 5°W)	cap-icel	Iceland Shelf/Sea and Greenland Sea
Faroe Plateau cod (Sub-division Vb1)	cod-farp	Faroe Plateau
Icelandic cod (Division Va)	cod-iceg	Iceland Shelf/Sea and Greenland Sea
Faroe haddock (Division Vb)	had-faro	Faroe Plateau
Icelandic haddock (Division Va)	had-iceg	Iceland Shelf/Sea and Greenland Sea
Icelandic summer-spawning herring (Division Va)	her-vasu	Iceland Shelf/Sea and Greenland Sea
Faroe saithe (Division Vb)	sai-faro	Faroe Plateau
Southern horse mackerel (Division IXa)	hom-soth	Iberian Coastal
Sardine in Divisions VIIIc and Ixa	sar-soth	Iberian Coastal
Cod in Sub-divisions 25 to 32	cod-2532	Baltic Sea
Herring in Sub-divisions 25 to 29 and 32 minus Gulf of Riga	her-2532-gor	Baltic Sea
Herring in Sub-division 30, Bothnian Sea	her-30	Baltic Sea
Sprat in Sub-divisions 22 to 32	spr-2232	Baltic Sea
Cod in Divisions VIIe-k	cod-7e-k	Celtic-Biscay Shelf
Haddock in Divisions VIIb-k	had-7b-k	Celtic-Biscay Shelf
Haddock in Division VIb (Rockall)	had-rock	Celtic-Biscay Shelf
Haddock in Division VIa (West of Scotland)	had-scow	Celtic-Biscay Shelf
Plaice in Division VIIe (Western Channel)	ple-echw	Celtic-Biscay Shelf
Sole in Divisions VIIf and g (Celtic Sea)	sol-celt	Celtic-Biscay Shelf
Sole in Division VIIe (Western Channel)	sol-echw	Celtic-Biscay Shelf
Sole in Division VIIa (Irish Sea)	sol-iris	Celtic-Biscay Shelf
Whiting in Divisions VIIe-k	whg-7e-k	Celtic-Biscay Shelf
Megrim (Boscii) in Divisions VIIIc and Ixa	mgb-8c9a	Iberian Coastal
Megrim (Whiffiagonis) in Divisions VIIIc and Ixa	mgw-8c9a	Iberian Coastal
Sole in Divisions VIIIa,b (Bay of Biscay)	sol-bisc	Iberian Coastal
Cod in Sub-area IV, Divison VIId & Division IIIa (Skagerrak)	cod-347d	North Sea
Haddock in Sub-area IV (North Sea) and Division IIIa	had-34	North Sea
Plaice in Division VIId (Eastern Channel)	ple-eche	North Sea
Plaice Sub-area IV (North Sea)	ple-nsea	North Sea
Saithe in Sub-area IV, Division IIIa (Skagerrak) & Sub-area VI	sai-3a46	North Sea
Sole in Division VIId (Eastern Channel)	sol-eche	North Sea
Sole in Sub-area IV (North Sea)	sol-nsea	North Sea
Whiting Sub-area IV (North Sea) & Division VIId (Eastern Channel)	whg-47d	North Sea
Norwegian spring-spawning herring	her-noss	Barents Sea and Norwegian Sea
Western horse mackerel (Divisions Iia, IIIa, Iva, Vb, VIa, VIIa-c, VIIe-k, VIIIa,b,d,e)	hom-west	North Sea, Barents and Norwegian Seas, and Celtic-Biscay Shelf
Mackerel (combined Southern, Western & N.Sea spawn.comp.)	mac-nea	North Sea, Barents and Norwegian Seas, and Celtic-Biscay Shelf
Blue whiting combined stock (Sub-areas I-IX, XII & XIV)	whb-comb	North Sea, Barents and Norwegian Seas, Celtic-Biscay Shelf and Iberian Coastal

How much fish has been lost to overfishing?

The quantity of fish, in tonnes, that has been foregone due to overfishing is calculated as the absolute difference between current (2010[35]) landings[36] and the MSY for each stock. Given that the MSY estimates are, by definition, the maximum that can be sustained, any deviation from this must be considered as either overfishing or underfishing, and therefore a loss. In European stocks (and especially those studied here), however, the issue of underfishing is a very small one. Overfishing can lead to catches that are below MSY because the stock size has been diminished (and so too has its productivity), but can also lead to catches above MSY when the stock is currently being overfished. In both cases, the solution is to reduce fishing pressure to allow stocks to rebuild to levels that support MSY.

How was overfishing given monetary values?

This absolute difference between MSY and current (2010) landings was valued using a price per tonne for each species, for each region. This is more accurate than a generic price per species, as is often used in fisheries economics, because prices vary widely across regions for the same species. The prices were calculated by dividing the tonnes landed by their monetary values.[37] It is worth noting that a species price – as they are available – does not necessarily correspond to a single stock, but in many cases does. For example, Atlantic cod landed in the North Sea region is necessarily from the North Sea cod stock (cod 347d). The macro database we used was also the most easily accessible and covers the entire study area. Other data sources are far more time-consuming, and involve data collection from Government fisheries ministries from each of the 45 countries in the study.

Prices were calculated by dividing the tonnes landed in each LME[38] during a five year period (2002-2006) by the respective year and species-specific values.[39] These values were in real 2000 terms (US$); values in 2002, for example, had been converted to their real value equivalent in the year 2000. For each year, we adjusted these values back to their nominal values,[40] converted them to Euro equivalents in the landing year,[41] and then inflated to their 2010 real term (Euro) equivalents.[42,43] We then averaged the values over the five-year period to obtain final estimates of price per tonne per species per region. These prices were multiplied by the lost catch to estimate total lost value (or, equally, the potential value of rebuilding stocks).

To attribute these values to different fishing countries we used data on the relative catch values per region per country.[44] In doing this, we assume that relative catch values would remain with rebuilt stocks, and that these are region-specific, not stock or species-specific. For example, if the UK caught 26% of the total value of fish catches in the North Sea in all years, we then assume that the UK stands to benefit from the UK's average share (26%) of restoring all the North Sea stocks. However, while value shares per country must together sum to total values, this is not true of the multi-annual averages; we therefore scaled all averages proportionately to ensure the multi-annual average country shares also summed to 1 (total value).

Although not currently available for all stocks studied here, future estimates of country-specific values (benefits of rebuilding stocks) could take advantage of data on landings per country per stock, available from ICES.[45] Additionally, this paper is not intended as a market analysis, and as such we did not simulate possible market reactions to changes in landings as stocks are restored – the prices we used are current prices. Interestingly, while the amounts of fish can be enormous, the prices are very low, ranging from €0.12/kg for Icelandic herring to €3.60/kg for Megrim.

How did we estimate the number of jobs lost?

Estimating the numbers of jobs lost due to overfishing was done by using country-specific employment figures in fishing and processing. First, this required country-specific monetary values, as estimated above. Second, we estimated the numbers of FTE jobs these could support based on current employment per million Euros of landings.[46] This was itself calculated by dividing total full-time employment in fishing by landing values (in millions of Euros). These landing values were also adjusted for inflation to determine employment per million Euros in real 2010 terms. There were some data gaps, however, which required using data on both total and FTE fishers, and in particular the overlap (i.e. same year) between the two. Where

countries had insufficient data on (i) FTE fishers for all years, but did have sufficient data for total fishers for all years, we took the average ratio and applied it to the missing FTE years (ii) FTE fishers for all years, nor total fishers for all years, but with overlap in at least one year, then we applied the ratio to all years with data on total fishers to complement the existing data on FTE fishers (iii) all years for FTE and total fishers then this country was either excluded in cases of no fishing,[47] or applied an EU27 average.[48] Where we had complete information, we averaged FTE fishers per million euros of landings for all years in the period 2002–2010, and otherwise for the years we could estimate.[49]

To calculate the impact of restoring stocks on jobs in the processing sector, we estimated the ratio of FTE fishing jobs to processing jobs per country.[50] It is worth noting that data on processing jobs is more difficult to find and also encompasses full-time and part-time jobs.

It is also worth noting the significance of using current employment rates in fishing as a basis for estimating potential rates. Clearly, restoring stocks would increase sustainable landings, and revenues. However, how the industry would use these revenues is unknown. Would employment increase, or would current jobs simply do the extra work of catching more fish while profits increase?

Results

The following tables show our results:

- Table A3: MSY and current landings, with associated lost catches, values and employment per fish stock
- Table A4: MSY and current landings, with associated lost catches, values and employment per country fishing these fish stocks
- Table A5: Current employment in fishing and processing in the EU.

To put the employment figures into context, it helps to know what the current employment in fisheries is in the EU. While we used the AER[51] for our calculations, with the exception of processing jobs multipliers (see Table A5), for the purposes of contextualisation the EC report on the CFP reform is sufficient.[52] It shows that the EU27 has 141,110 full-time equivalent fishermen,[53] and a further 126,307 full and part-time jobs in processing. Spain has the most fishermen (35,274), followed by Italy (25,426), Greece (24,745), Portugal (14,445), France (13,155), the UK (8,064). Germany has 1,617. In processing, Spain is again the most significant (22,915), followed by the UK (16,660), Poland (16,096), France (14,099), Denmark (8,915), and Italy (7,750). Germany has 6,468 processors. Norway and Iceland are also prominent fishing countries in these areas; in 2007 Norway had 10,275 FTE fishers and 9,095 processors,[54] and Iceland had 4,500 fishers (including part-time) and 2,900 processors.[55]

Table A3: Costs of overfishing per fish stock.

Name	Stock ID	MSY (tonnes)	Landings in 2010 (tonnes)	Lost catch (tonnes)	Price per tonne (€)	MSY Revenue (€m)	Value of 2010 landings (€m)	Lost revenue (€m)	Lost employment: FTE Fishermen	Lost employment: Processing
Total (all stocks)		**9756519**	**6230564**	**3525955**	**-**	**7136.55**	**3948.96**	**3187.60**	**31802.45**	**68987.58**
North-East Arctic cod (Sub-areas I and II)	cod-arct	837049	609983	227066	1283.0	1073.93	782.61	291.33	2171.12	2236.60
North-East Arctic haddock (Sub-areas I and II)	had-arct	127387	249334	-121947	1107.3	411.12	276.09	135.03	1006.34	1036.69
North-East Arctic saithe (Sub-areas I and II)	sai-arct	192951	193399	-448	535.1	103.74	103.50	0.24	1.79	1.84
Herring in Sub-divisions 22-24 and Division IIIa (spring-spawners)	her-3a22	116470	42214	74256	355.4	41.39	15.00	26.39	545.76	2207.62
Herring in Sub-area IV, Divisions VIId & IIIa (autumn-spawners)	her-47d3	529790	187611	342179	256.7	135.98	48.15	87.82	686.94	1461.68
Herring in Division VIa (North)	her-vian	59344	19877	39467	249.7	14.82	4.96	9.86	123.88	137.91
Capelin, Iceland-East Greenland-Jan Mayen Area(V XIV IIa west 5°W)	cap-icel	957459	391000	566459	301.4	288.55	117.84	170.72	984.44	1053.38
Faroe Plateau cod (Sub-division Vb1)	cod-farp	22267	12737	9530	953.2	21.22	12.14	9.08	56.05	56.47
Icelandic cod (Division Va)	cod-iceg	388103	168880	219223	1206.9	468.38	203.81	264.57	1525.65	1632.48
Faroe haddock (Division Vb)	had-faro	15317	5198	10119	931.6	14.27	4.84	9.43	58.17	58.61
Icelandic haddock (Division Va)	had-iceg	61024	64169	-3145	1429.5	96.23	91.73	4.50	25.93	27.74
Icelandic summer-spawning herring (Division Va)	her-vasu	126943	44000	82943	118.5	15.05	5.22	9.83	56.69	60.66
Faroe saithe (Division Vb)	sai-faro	41624	43959	-2335	913.5	42.29	40.16	2.13	13.16	13.26
Southern horse mackerel (Division IXa)	hom-soth	32721	27217	5504	687.5	22.49	18.71	3.78	107.82	59.72
Sardine in Divisions VIIIc and Ixa	sar-soth	147329	89571	57758	417.4	61.49	37.38	24.11	686.90	380.49
Cod in Sub-divisions 25 to 32	cod-2532	255735	50277	205458	1323.6	338.50	66.55	271.95	5623.80	22748.39
Herring in Sub-divisions 25 to 29 and 32 minus Gulf of Riga	her-2532-gor	372837	136706	236131	355.4	132.51	48.59	83.92	1735.50	7020.13
Herring in Sub-division 30, Bothnian Sea	her-30	51579	71726	-20147	355.4	32.65	25.49	7.16	148.07	598.97
Sprat in Sub-divisions 22 to 32	spr-2232	388386	342000	46386	294.6	114.43	100.76	13.67	282.62	1143.21
Cod in Divisions VIIe-k	cod-7e-k	10889	3229	7660	1950.0	21.23	6.30	14.94	187.72	208.99
Haddock in Divisions VIIb-k	had-7b-k	23351	22000	1351	1223.9	28.58	26.93	1.65	20.78	23.13
Haddock in Division VIb (Rockall)	had-rock	11037	3710	7327	1223.9	13.51	4.54	8.97	112.70	125.47
Haddock in Division VIa (West of Scotland)	had-scow	22745	4824	17921	1223.9	27.84	5.90	21.93	275.65	306.88
Plaice in Division VIIe (Western Channel)	ple-echw	1883	1227	656	1223.9	2.30	1.50	0.80	10.09	11.23
Sole in Divisions VIIf and g (Celtic Sea)	sol-celt	989	862	127	1364.7	1.35	1.18	0.17	2.18	2.43
Sole in Division VIIe (Western Channel)	sol-echw	1051	688	363	1364.7	1.43	0.94	0.50	6.23	6.93
Sole in Division VIIa (Irish Sea)	sol-iris	1494	275	1219	1364.7	2.04	0.38	1.66	20.91	23.28
Whiting in Divisions VIIe-k	whg-7e-k	13421	8500	4921	1250.3	16.78	10.63	6.15	77.33	86.09
Megrim (Boscii) in Divisions VIIIc and Ixa	mgb-8c9a	1302	1297	5	3599.9	4.69	4.67	0.02	0.51	0.28
Megrim (Whiffiagonis) in Divisions VIIIc and Ixa	mgw-8c9a	644	83	561	3599.9	2.32	0.30	2.02	57.55	31.88
Sole in Divisions VIIIa,b (Bay of Biscay)	sol-bisc	7107	3966	3141	1364.7	9.70	5.41	4.29	122.15	67.66
Cod in Sub-area IV, Divison VIId & Division IIIa (Skagerrak)	cod-347d	373543	69286	304257	1660.0	620.07	115.01	505.06	3950.48	8405.91
Haddock in Sub-area IV (North Sea) and Division IIIa	had-34	259119	39640	219479	1459.9	378.28	57.87	320.41	2506.21	5332.76
Plaice in Division VIId (Eastern Channel)	ple-eche	8810	3177	5633	1724.5	15.19	5.48	9.71	75.98	161.68
Plaice Sub-area IV (North Sea)	ple-nsea	162123	106500	55623	1724.5	279.58	183.66	95.92	750.28	1596.47
Saithe in Sub-area IV, Division IIIa (Skagerrak) & Sub-area VI	sai-3a46	156804	102500	54304	657.8	103.14	67.42	35.72	279.39	594.50
Sole in Division VIId (Eastern Channel)	sol-eche	4496	4391	105	1364.7	6.14	5.99	0.14	1.12	2.38
Sole in Sub-area IV (North Sea)	sol-nsea	18742	12600	6142	1364.7	25.58	17.20	8.38	65.56	139.51
Whiting Sub-area IV (North Sea) & Division VIId (Eastern Channel)	whg-47d	45767	21947	23820	1105.8	50.61	24.27	26.34	206.03	438.40
Norwegian spring-spawning herring	her-noss	1515458	1457014	58444	235.3	356.65	342.89	13.75	102.50	105.60
Western horse mackerel (Divisions IIa, IIIa, IVa, Vb, VIa, VIIa-c, VIIe-k, VIIIa,b,d,e)	hom-west	370376	204000	166376	687.5	254.62	140.24	114.38	1125.68	1569.80
Mackerel (combined Southern, Western & N.Sea spawn.comp.)	mac-nea	676655	869451	-192796	723.0	768.03	628.63	139.40	1371.93	1913.20
Blue whiting combined stock (Sub-areas I-IX, XII & XIV)	whb-comb	1344398	539539	804859	534.0	717.85	288.09	429.76	4632.84	5897.30

Table A3: The maximum (MSY), current (2010), lost catch per stock due to overfishing, the price per tonne for each stock, and the value of this loss in real 2010 Euro values. The lost employment (fishers and processors) is also shown.

Table A4: Costs of overfishing per country.

Country/Region	MSY (tonnes)	Landings in 2010 (tonnes)	Lost catch (tonnes)	MSY Revenue (€m)	Value of 2010 landings (€m)	Lost revenue (€m)	Employment: FTE Fishermen	Employment: Processing
Total	**9756519**	**6230564**	**3525955**	**7136.6**	**3949.0**	**3187.6**	**31802.5**	**68987.6**
Europe (incl. 'others')	9743834	6223580	3520255	3946.1	3946.1		31726.4	68919.5
Europe (not incl. 'others')	9515598	6071360	3444238	3845.6	3845.6		30362.8	67699.0
EEA (EU27 + NO + IS + IL)	7744075	4696333	3047742	5679.4	2986.2	2693.2	27793.9	65375.3
EU27	4381421	2383327	1998093	3358.0	1538.0	1820.0	22409.2	60503.8
Austria	0	0	0	0.0	0.0	0.0	0.0	0.0
Belgium	68159	37220	30939	58.7	27.7	31.0	145.9	396.5
Bulgaria	0	0	0	0.0	0.0	0.0	0.0	0.0
Cyprus	0	0	0	0.0	0.0	0.0	0.0	0.0
Czech Republic	0	0	0	0.0	0.0	0.0	0.0	0.0
Denmark	550091	226206	323885	487.0	164.5	322.5	2132.4	5720.1
Estonia	86077	46895	39182	48.0	18.9	29.1	163.9	1395.6
Finland	212380	115226	97154	118.2	46.0	72.2	539.9	216.8
France	631910	408311	223600	487.2	280.8	206.4	2948.2	3159.8
Germany	356498	196820	159678	272.2	125.9	146.4	1485.1	8187.9
Greece	0	0	0	0.0	0.0	0.0	0.0	0.0
Hungary	0	0	0	0.0	0.0	0.0	0.0	0.0
Ireland	28418	12672	15746	25.2	12.3	13.0	178.9	97.2
Italy	0	0	0	0.0	0.0	0.0	0.0	0.0
Latvia	114872	62883	51989	64.2	25.4	38.8	2692.6	10148.4
Lithuania	28056	16063	11993	16.0	6.8	9.2	214.8	1326.9
Luxembourg (Grand-Duché)	0	0	0	0.0	0.0	0.0	0.0	0.0
Malta	0	0	0	0.0	0.0	0.0	0.0	0.0
Netherlands	229973	81480	148493	237.0	78.2	158.9	803.1	1350.1
Poland	137300	74260	63040	77.0	29.9	47.1	2762.0	16687.9
Portugal	58540	37809	20732	31.2	20.6	10.6	481.0	215.4
Romania	0	0	0	0.0	0.0	0.0	0.0	0.0
Slovakia	0	0	0	0.0	0.0	0.0	0.0	0.0
Slovenia	0	0	0	0.0	0.0	0.0	0.0	0.0
Spain	384081	219514	164567	233.9	131.5	102.5	2159.6	1402.9
Sweden	446457	266653	179804	303.1	140.6	162.6	1974.2	2497.4
United Kingdom	1048608	581317	467292	898.9	429.1	469.8	3727.5	7700.9
Algeria	0	0	0	0.0	0.0	0.0	0.0	0.0
Croatia	0	0	0	0.0	0.0	0.0	0.0	0.0
Egypt	0	0	0	0.0	0.0	0.0	0.0	0.0
Faeroe Isl. (Denmark)	486334	356452	129882	372.3	238.6	133.7	650.9	600.9
Former Yugoslav Republic of Macedonia, the	0	0	0	0.0	0.0	0.0	0.0	0.0
Greenland	85838	37394	48445	48.6	23.4	25.2	122.5	113.1
Iceland	1178935	544737	634198	679.3	340.7	338.6	1648.3	1521.7
Japan	12685	6985	5700	7.0	2.9	4.2	76.1	68.1
Libya	0	0	0	0.0	0.0	0.0	0.0	0.0
Liechtenstein	0	0	0	0.0	0.0	0.0	0.0	0.0
Morocco	0	0	0	0.0	0.0	0.0	0.0	0.0
Norway	2183719	1768269	415451	1642.0	1107.5	534.5	3736.4	3349.7
Russian Federation	1199351	981181	218169	854.2	597.3	256.9	1795.6	1609.8
Switzerland	0	0	0	0.0	0.0	0.0	0.0	0.0
Tunisia	0	0	0	0.0	0.0	0.0	0.0	0.0
Turkey	0	0	0	0.0	0.0	0.0	0.0	0.0
Ukraine	0	0	0	0.0	0.0	0.0	0.0	0.0
Others	228236	152220	76016	175.0	100.5	74.5	1363.6	1220.5

Table A4: The costs of overfishing – in catch, value and employment – on a per country basis for the 43 fish stocks studied. Note that the southern European countries, such as Spain, Italy, Greece and even France will have substantially higher costs to overfishing than our results show, because the Mediterranean is not represented in this study. All monetary values in real 2010 Euro terms. While fishing jobs are all FTE, processing jobs are full and part-time employment.

Table A5: Current employment in fishing and processing in the EU.

Country/Region	FTE jobs / €m landings	Processing jobs: Multiplier	Processing jobs / €m landings
Austria	-	-	-
Belgium	4.71	2.72	12.79
Bulgaria	514.19	-	-
Cyprus	74.63	0.00	0.00
Czech Republic	-	-	-
Denmark	6.61	2.68	17.74
Estonia	5.62	8.51	47.88
Finland	7.47	0.40	3.00
France	14.28	1.07	15.31
Germany	10.15	5.51	55.94
Greece	56.96	0.06	3.44
Hungary	-	-	-
Ireland	13.81	0.54	7.51
Italy	18.60	0.30	5.67
Latvia	69.41	3.77	261.59
Lithuania	23.42	6.18	144.68
Luxembourg (Grand-Duché)	-	-	-
Malta	-	-	-
Netherlands	5.05	1.68	8.50
Poland	58.59	6.04	354.01
Portugal	45.42	0.45	20.34
Romania	649.03	-	-
Slovakia	-	-	-
Slovenia	59.44	2.14	127.02
Spain	21.07	0.65	13.69
Sweden	12.14	1.27	15.36
United Kingdom	7.93	2.07	16.39
EU Average	18.80	0.90	16.83
Algeria	18.30	0.90	16.38
Croatia	18.30	0.90	16.38
Egypt	18.30	0.90	16.38
Faeroe Isl. (Denmark)	4.87	0.92	4.49
Former Yugoslav Republic of Macedonia, the	18.30	0.90	16.38
Greenland	4.87	0.92	4.49
Iceland	4.87	0.92	4.49
Japan	18.30	0.90	16.38
Libya	18.30	0.90	16.38
Liechtenstein	18.30	0.90	16.38
Morocco	18.30	0.90	16.38
Norway	6.99	0.90	6.27
Russian Federation	6.99	0.90	6.27
Switzerland	18.30	0.90	16.38
Tunisia	18.30	0.90	16.38
Turkey	18.30	0.90	16.38
Ukraine	18.30	0.90	16.38
Others	18.30	0.90	16.38

Table A5: Fishing and processing employment per country (per million Euros of landings). Some countries were excluded due to lack of fishing or data on employment, while for others we applied an EU27 average where there were problems with the data or its collection. Euros in 2010 real terms.

How our results relate to other studies

Our estimates are generally consistent with the literature on the costs of overfishing. In some cases, they show themselves to be more conservative. Some examples include:

- The *Sunken Billions* report estimated the global annual cost of overfishing at US$50 billion (in 2009 terms).[56]

- A recent Defra-commissioned study[57] found the UK stands to gain £425 million per annum through restoring stocks. This compares to our estimate of £403 million per annum (€470m).[58] This same report uses a 35% inflator to estimate the potential value under conditions of more value added in the market, bringing the maximum gains to the UK to £574m/yr. Applying this same inflator to our result would lead to a UK benefit of £544m/yr.

- Using job estimates from a recent consultancy report,[59] the cost of overfishing to jobs in all countries would be 134,345 jobs. Our estimates are significantly lower than this.

Improving the study

The study is based on many data sources and methods

1. Including all EU stocks: there are over 150 stocks in EU (and European) waters, and this does not include fishing by the distant water fleet or imports. Estimating the value of rebuilding stocks to the EU27 should include all stocks that support EU27 fish consumption (human, animal and other uses).

2. Ecosystem dynamics, MMSY and environmental factors: the MSY estimates we use may together overestimate the value of restoring fish stocks by not accounting for dynamic ecosystem feedback (e.g. predator-prey relationships). There is also evidence that, as climate change progresses, the restoration potential (and MSY estimates) are affected.[60,61] This is also the case for direct human impacts, such as fishing-related ecosystem alteration such as regime shifts changing the species abundance, diversity and restoration potential.[62]

3. Market dynamics: adjusting prices to reflect changes in landing weights as stocks are rebuilt.

4. Country and stock-specific proportions: currently data does not cover this for all stocks in this study, but does for some.

5. There are other improvements that could be made around lost catch, their value (prices) and jobs they could support. The accuracy of this data all depends on the spatial resolution: at their best, the figures would be stock and port-specific, but this data is simply not practical or, in most cases, even available.

Endnotes

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32 There are many ways to estimate MSY. Froese and Proelß yield-per-recruit and mean recruitment, mean expected biomass-per-recruit and mean recruitment, and surplus production analysis. The upper and lower 95% confidence limits are also published.

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39 With the exception of stocks living in Icelandic and East of Greenland waters (4 stocks), those living in Celtic-Biscay Shelf, North Sea and Baltic Sea (2 stocks), and those living in the Celtic-Biscay Shelf, North Sea, Baltic Sea and Iberian Coastal (1 stocks), where the MSY estimates are not distinguished between these LME's; prices for landings from these areas were, therefore, averaged (weighted by relative landing values) for each species.

40 Inflation-adjustment to nominal values used annual-average inflation rates (Consumer Price Index (CPI)), compounded for multiple years, using the United States Minnesota Federal Reserve.
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43 Overall, this lead to a multiplication of 0.9774 for landings made in 2002, 0.9730 for landings made in 2003, 0.9914 for landings made in 2004, 1.008 for landings made in 2005, and 0.9936 for landings made in 2006.

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48 The EU27 average was calculated similarly by dividing total FTE fishers in the EU27 by the value of landings, where both numerator and denominator were calculated in an internally consistent way using the same member state data. The average EU27 processing employment rates (multiplier and employment per million Euros landed) were calculated as with other countries.

49 The period 2002–2010 was used to increase the data frame for estimating FTE fishers.

50 This was calculated by dividing the numbers of FTE fishers by the number of processors in each country/region.

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If you have any feedback, comments or suggestions to improve this report we would love to hear from you.

E-mail: info@neweconomics.org

new economics foundation
3 Jonathan Street
London SE11 5NH
United Kingdom
Telephone: +44 (0)20 7820 6300
Facsimile: +44 (0)20 7820 6301
E-mail: info@neweconomics.org
Website: www.neweconomics.org

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