## DiscardLess

### 8.2 Celtic Sea case study

### 8.2.1 Brief presentation of the CS and fisheries concerned

The case study is focused on the demersal trawl fisheries in the Celtic Sea, principally carried out by Irish and French vessels, within an area shown approximately in the Figure 12.


Figure 12: Map of the region covered in the Celtic Sea Case Study.

DiscardLess

### 8.2.1.1 The Irish fisheries

There are six main metier involved from Ireland:

- GNS VIIbcgjk Dem - Trips carried out within VIIb, VIIc, VIIg, VIIj, or VIIk using gillnets to target demersal species, such as saithe, ling, and pollack; cod; rays; hake and forkbeard.
- OTB VIIgfhNeph - Bottom otter trawl trips using a codend mesh size of between 70 and 119 mm , fishing within the VIIf-h area targeting Nephrops. The Nephrops component of landings constitutes at least $40 \%$ of total trip landings.
- OTB VIIjNeph - Bottom otter trawl trips using a codend mesh size of between 70 and 119 mm , fishing within VIIj targeting Nephrops. The Nephrops component of landings constitutes at least 35\% of total triplandings.
- SSC VIIgj Dem - Trips carried out within VIIg or VIIj using Scottish seines of mesh size 70 mm or moreto target demersal species, primarily haddock and whiting.
- TBB VIIefgh Dem - Trips carried out within the VIIe-h area using beam trawls with mesh sizes between 80 mm and 89 mm to target demersal species, like ray and flatfish species, and megrim, monkfish, witch and lemon sole.
- OTB VIIfgjk Dem - Bottom otter trawl trips, regardless of codend mesh size, fishing within VIIf, VIIg, VIIjand VIIk targeting demersal species. Target species groups include whitefish, and ray and flatfish species.

The case study will focus mainly on the OTB metiers.

Overall areas and metiers, discarding has been declining in recent years (see Figure 13), but can still be considered high.


Figure 13: Percentage discard rate of the 'top 10' commercial species.

## DiscardLess

The discard rates by species for all Irish fisheries are shown in the tables below. Table 4 shows discarding for commercial fish and shellfish, and the

Table 5 shows the rates for the non-commercial fish.

Table 4: Top 10 Commercial Fish Species Landed (by weight) from 2003-2009 Caught by Demersal Gears

| Species | Discards | Landings | Total Catch | Discard <br> Rate | Annual Average <br> Discarded |
| :--- | ---: | ---: | ---: | ---: | ---: |
| Nephrops | 11,194 | 51,808 | 63,312 | $18 \%$ | 1,599 |
| Haddock | 34,532 | 28,773 | 63,306 | $55 \%$ | 4,933 |
| Whiting | 23,246 | 19,410 | 42,656 | $54 \%$ | 3,321 |
| Megrim | 6,230 | 14,902 | 21,132 | $29 \%$ | 890 |
| Hake | 6,521 | 12,422 | 18,942 | $34 \%$ | 932 |
| Monkfish | 2,756 | 12,276 | 15,032 | $18 \%$ | 394 |
| Cod | 1,140 | 8,848 | 9,988 | $11 \%$ | 163 |
| Plaice | 9,912 | 3,973 | 13,885 | $71 \%$ | 1,416 |
| Saithe | 468 | 2,963 | 3,430 | $14 \%$ | 67 |
| Witch | 2,278 | 2,271 | 4,549 | $50 \%$ | 325 |
| Total | 98,277 | 157,645 | 255,922 | $38 \%$ | 14,040 |
| Annual Average | 14,039 | 22,251 | 36,560 |  |  |

Table 5: Top 10 Non-Commercial Fish Species (by weight) from 2003-2009 caught by Demersal Gears

| Species | Total Catch | Discard Rate | Annual Average <br> Discarded |
| :--- | ---: | ---: | ---: |
| Lesser Spotted Dogfish | 12,863 | $100 \%$ | 1,835 |
| Grey Gurnard | 12,211 | $100 \%$ | 1,744 |
| Dab | 5,973 | $100 \%$ | 853 |
| Blue Whiting* | 5,244 | $100 \%$ | 749 |
| Forkbeard | 3,255 | $100 \%$ | 463 |
| Poor Cod | 3,031 | $100 \%$ | 433 |
| Scad* $^{*}$ | 2,820 | $100 \%$ | 403 |
| Boar-fish* $_{\text {Argentinidae* }}$ Long Rough Dab | 2,086 | $100 \%$ | 298 |
| Lotal | 1,890 | $100 \%$ | 270 |
| Annual Average | 1,292 | $100 \%$ | 185 |

The discard rates for the top 10 commercial species in the Celtic Sea are shown in the Table 6.
Table 6: Table Discard rate by species by weight for nine major commercial species in the Celtic Sea.

| Species | Discard rate (\%) | Species | Discard rate |
| :--- | :--- | :--- | :--- |
| Haddock | 50 | Cod | 11 |
| Whiting | 43 | Plaice | 73 |
| Megrim | 31 | Witch | 30 |
| Hake | 29 | Nephrops | $11-48$ |
| Monkfish | 29 | Saithe | 1 |

Research into discarding in the Celtic Sea mixed demersal fishery has been limited. The most important published work is by Rochet et al 2002, and Borges et al 2005. The fishery was also a case study in the MariFish funded project BADMINTON (BycatchAnd Discards: Management Indicators, Trends and locatiON).

### 8.2.1.2 French fisheries

Definitions of metiers are distinct between DCF and annual report of the observer at sea program. Because the main focus of this factsheet is discarding, we provide information based on observer at sea metier classification. Most of the figure and table come from annual synthesis of OBSMER (Cornou et al 2015, 2013).

There are four main metiers involved from France:

- OT_CRU bottom trawl trips targeting Nephrops in ICES division VIIf, VIIg,VIIh andVIIk (Figure 14). This metier involves both OTB and OTT. Landings of Nephrops by this French fleet are decreasing in recent years, effort being reallocated to whitefish and anglerfish. Discard rate for this metier is around 13-15 \% (Table 7) and are mainly composed of hake and nephrops ( $14 \%$ and $22.5 \%$ of the discards in 2013 respectively) followed by megrim, anglerfish and small spotted catfish that account for around $5 \%$ of the discard each (Cornou et al. 2015,Table 8).
- OT_DEF bottom trawl trips targeting whitefish and benthic fish in ICES division VII (excepted VIId, Figure 14). This metier targets both gadoids in the central Celtic sea including VIIe and benthic species (ray, megrim and anglerfish) in the Celtic sea and Acores. Since 2012, a square mesh panel is mandatory. The yearly average discard rate is around 20-25 \% (Table 7). It varies across area and season (from 10 to 35\%). Due to the large spatial coverage of this fishery discards are highly diverse (more than 100 species). Discards are mainly composed by haddock, whiting, boarfish, small spotted catfish and Red gurnard (Cornou et al. 2015,Table 8).
- GIL_DEF/CEPgillnets trips targeting demersal species, cephalopods and crustaceans along the northern cost of Brittany (Figure 14, VIIh and VIIe). This metier includes both GNS and GTR nets and is represented by two vessels category inferior and superior to 15 m . Discards rate varied between 15 and 20\% between 2012 and 2013. Discards are mainly composed by anglerfish, rays and crabs (including spider crabs)(Cornou et al. 2015,Table 8).
- OT_DEF_VIIe bottom trawl targeting demersal, benthicspecies and cephalopods inVIIe specifically. In average the vessels length are lower than the OT_DEF operating in the central Celtic sea (inferior and superior to 18 m ). In terms of discard, the discard rate is higher than the other OT_DEF metier with a discard rate between $40-80 \%$ depending on the quarter (around $60 \%$ in average)(Cornou et al. 2015, Table 8).
- Other metiers operate in the Celtic sea: OT-DWS are bottom trawler targeting deep water speciesthat mainly operate in ICES division VI and VII but with little catches in area VIIc. In recent year a Danish seine metier enters the fisheries, but little information are available to date (Cornou et al. 2015).


Figure 14: Spatial coverage of observed fishing operation (circles) and effort (collored statistical rectangle) in days at sea in 2013. Top left (OT_CRU), top right(OT_DEF), bottom left (GIL_DEF_CEP<15m), bottom right(OT_DEF_VIIe).

Table 7. Estimate of total catch, landings, discards in tons and discard rate per metier for species under quota (Obsermer 20132012).

| Year | Métier | Vessel Length | Total Catch ( t$)$ | landings ( t ) | Discards ( t ) | Discards rate (\%) |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 2013 | OT_CRU | NA | NA | NA | NA | $13[11-15.4]$ |
| 2013 | OT_DEF | $>18 \mathrm{~m}$ | $57610[45460-69759]$ | $44750[34163-55833]$ | $12860[9076-17336]$ | $22.3[20-24.9]$ |
| 2013 | GIL_DEF/CEP | $<15 \mathrm{~m}$ | $5840[5137-6541]$ | $4641[3932-5369]$ | $1199[920-1535]$ | $20.5[17.9-23.5]$ |
| 2013 | GIL_DEF/CEP/CRU | $>15 \mathrm{~m}$ | $2884[2648-3120]$ | $2354[2080-2637]$ | $530[410-669]$ | $18.4[15.5-21.5]$ |
| 2013 | OT_DEF | $<18 \mathrm{~m}$ in VIIe | $8920[6622-11221]$ | $3272[1961-4997$ | $5648[3673-7898]$ | $63.3[55.5-70.4]$ |
| 2012 | OT_CRU | NA | NA | NA | NA | $15.8[13.6-18.2]$ |
| 2012 | OT_DEF | $>18 \mathrm{~m}$ | $58044[42802-73286]$ | $44222[31590-57358]$ | $13822[9303-19198]$ | $23.8[21.7-26.2]$ |
| 2012 | GIL_DEF/CEP | $<15 \mathrm{~m}$ | $3955[3735-4174]$ | $3330[3054-3605]$ | $625[510-761]$ | $15.8[13.8-18.2]$ |
| 2012 | GIL_DEF/CEP/CRU | $>15 \mathrm{~m}$ | $2305[2080-2533]$ | $1768[1512-2042]$ | $537[403-692]$ | $23.3[19.4-27.3]$ |
| 2012 | OT_DEF | $<18 \mathrm{~m}$ in VIIe | $4234[22.33-6233]$ | $1680[705-3001]$ | $2554[1158-4265]$ | $60.3[51.9-68.4]$ |

Table 8: Discards(in tons) of species under quota in any ICES division per metier in 2013.

| Species | OT_DEF | $\begin{aligned} & \text { GIL_DEF } \\ & \text { _CEP<15 } \end{aligned}$ | $\begin{aligned} & \text { GIL_DEF } \\ & \text { _CEP>1 } \end{aligned}$ | OT_DEF_VIIe | Total |
| :---: | :---: | :---: | :---: | :---: | :---: |
| Sea bass | 0 |  |  | 14.5 | 15 |
| Brill | 0 | 3.6 | 3.9 | 8.5 | 16 |
| monkfish | 521 | 140.3 | 52.2 | 3.5 | 717 |
| Alfonsino | 13.9 |  |  |  | 14 |
| Megrim | 409.2 | 0 | 0 | 0 |  |
| Blackmouthed | 86.4 |  |  |  | 86 |
| Scad | 248.3 |  |  | 2.5 | 251 |
| Haddock | 1484.9 | 1.1 |  |  | 1486 |
| Argentinidae | 32.6 |  |  |  | 33 |
| Hering | 37.6 |  |  |  | 38 |
| Nephrops | 40.3 |  |  |  | 40 |
| Pollack | 0 | 34.7 | 8.3 |  | 43 |
| Saithe | 6.8 | 0.6 |  |  | 7 |
| Common dab | 93.2 |  |  | 7.9 | 101 |
| Lemon Sole | 36.2 |  |  |  | 36 |
| Ling | 27.2 | 28.3 | 22.4 |  | 78 |
| Blue Ling | 38.8 |  |  |  | 39 |
| Mackerel | 77.3 |  |  | 0 | 77 |
| Whiting | 754.3 | 1.1 | 2.8 | 53.9 | 812 |
| Blue Whiting | 14 |  |  |  | 14 |
| Hake | 316.9 | 10.7 | 3 |  | 331 |
| Cod | 49.9 | 32 | 15 | 0 | 97 |
| Greater forkbeard | 294.1 |  |  |  | 294 |
| Plaice | 97.5 | 1 |  | 28.2 | 127 |
| Rays | 385.6 | 180 | 94.5 | 581.4 | 1242 |
| Cutlassfish | 69.9 |  |  |  | 70 |
| Boar fish | 1863.5 |  |  |  | 1864 |
| red beam | 288.4 |  |  |  | 288 |
| Sole | 0 | 1.3 |  | 58.9 | 60 |
| Sharks | 168.8 | 0 | 0 | 0 | 169 |

### 8.2.2 Causes of discarding

The main reasons for discarding of commercial species in these fisheries would be due to lack of quota, or fish below minimum landing size (MLS). Market based drivers will also occur where there is no market opportunities or low prices. There may be some discarding under the last category from high grading practices, but that is not common in this fishery.

- Discarding of haddock, whiting, hake, monkfish, plaice, and witch is predominately associated with the capture of small unmarketable/undersize fish
- Megrim is discarded due to the retention of fish below minimum landings size and for quality considerations. There isa strong market preference for undamaged fish.
- Cod are mainly discarded due to quota restrictions, although undersized fish have become more important in recent years.
- Discarding of Nephrops is mainly limited to smaller or damaged individuals. Discard rates are highly variable, mainlydriven by market demand for smaller Nephrops
- Discards of Lesser Spotted Dogfish, grey gurnard, dab, poor cod, and long rough dab are mainly due to lack of market for these fish
- Discards of the pelagic species; blue whiting, poor cod, horse mackerel, boar fish, and argentines are mainly due to a lack of market for these fish from demersal fishing.


### 8.2.3 Effects of discarding

### 8.2.3.1 Mortality of discards and escapees

Discard survival work is limited, and the best work has been done by Benoit et al (2010, 2012, 2103), that suggests that discard survival can be high in some species, but depends on handling, exposure times and size. Flatfish discard mortalities (Revill et al 2013) were estimated at around 60\%, dependent on size and season. Highest survival is expected from elasmobranch species (Enever et al 2009). This shows that survival of rays can be around $50 \%$, but depends on handling, and the size of the catch. Revill et al (2009) found survival rates for lesser spotted dogfish of up to $96 \%$. Little is known about survival of either discards or escapees for most species. The most relevant researchon escape mortality remains that of Breen \& Cook (2002) and Ingólfsson et al (2007). In the latter escape survival was high for cod, but lower, and size dependent for haddock

### 8.2.3.2 Ecological effects of discarding

Relatively little research has been done on the ecosystem effects of discarding in this area. The best overall treatment of the effects of stopping discards was by Heath et al (2014) which showed that landing the entire catch while fishing as usual has conservationpenalties for seabirds, marine mammals and seabed fauna, and no benefit to fish stocks.However, combining landing obligations with changes in fishing practices to limit the captureof unwanted fish results in trophic cascades that can benefit birds, mammals and mostfish stocks. Viana et al (2014) showed the impact of discarding on the trophic Level of the overall catch.

### 8.2.3.3 Economic effects of discarding

SeaFish (2014) concluded that, with the various exemptions and flexibilities that can be applied, and with currentswaps, the North Sea whitefish and Neohrops fleets would be able to continue operating profitably. However, this was less likely for the Irish Sea Nephrops fishery. With considerable caution, this conclusion could very tentatively be extended to Celtic Sea demersal fisheries.

In a small scale analysis of the effect of the LO on specific Irish fisheries, it was shown that the LO would reduce profits in those vessels studied (Figure 15).


Figure 15: Summary economic results for trial vessels under Business As Usual (BAU), Landing Obligation (LO) and Quota Uplift (QUP) scenarios

### 8.2.4 Discard sampling

### 8.2.4.1 Ireland

The demersal catch sampling programme conducted by the Marine Institute (MI) is carried out using acombination of port based and at sea sampling methods. The combined port and seabased sampling programme (catch) commenced in 1993 and has one of the longest time series of discarddata in Europe.The initial work undertaken between 1993 and 1994 focused on developing the new methods required for monitoring discard and landings in Ireland. Sampling was based according to the trawl fleet activity in each port. In 1995 the standardised fleet discard monitoring programme commenced.
his project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 633680


DiscardLess

Gear type, areas and season can all have an influence on catches and therefore discards. It is therefore important that programmes to monitor landings and discards cover all the main fisheries. In this context,fisheries are defined as a group of vessel targeting the same species, using similar gear, during the same period of the year and within the same area e.g. the Irish flatfish-directed beam trawl fishery in the Irish Sea.A group of vessels engaged in a fishery e.g. twin-rig trawlers targeting Nephrops using an 80 mm mesh in theIrish Sea, is known as a métier. This is a very important concept in the sampling of discards. In Ireland, over 50 individual trawl métiers have been identified (Davie \& Lordan 2011 . In 2003, the Marine Institute revised the focus ofthe catch sampling programme to a more fleet based approach (i.e. métier approach) to better serve theData Collection Regulation (EC No. 1639/2001).

The métiers chosen for the Marine Institute's catch sampling programme are based on a number of factors. Firstly, it is based on the effort (métier activity i.e. hours fished) and the sampling (no. of trips) is structured in order to be representative of the métier activity. The effort distribution of Irish Vessels by gear type derived from Vessel Monitoring Systems (VMS) data (2005-2009) and the distribution of effort from discard sampled trips (1995-2009) are shown in the Figure 16.


Figure 16: Effort distribution of Irish Vessels by gear type from VMS database 2005-2009 (left side maps) andfrom discard sampled trips (1995-2009) (right side maps). TBB - TwinBeam Trawl; OTB - Demersal Otter Trawl. The scales show fishing intensity per year in terms ofthe hours fished per square nautical mile per year. The maps on the left show the effort of the>15m commercial fleet; the right hand maps show the amount of effort on observed sampling trips.

Other factors considered when choosing métiers to sample include resource constraints (i.e. availability ofMI staff), relative importance of the métier to the Irish fishing industry, emerging
fisheries (i.e. new métiers)and or fisheries with special considerations (e.g. boats using grids in the Irish Sea).

For both the port based and sea based sampling, the Marine Institute divides the Irish coast into five broadareas; the Celtic Sea, Irish Sea, West of Ireland, West of Scotland and Rockall. Within each of these areas, a number of ICES Divisions and métiers may exist.

### 8.2.4.1.1 Coverage of total effort

Coverage of total effort is less than $1 \%$. The distribution of discard sampling by metier is shown in the Figure 17.


Figure 17: Map showing the distribution of hauls sampled by métier (2003-2009).
The sampling coverage by metier is shown in the Table 9.

Table 9: Irish Sampling coverage by metier in the Celtic Sea.

| Area | Métier | 2003 | $\mathbf{2 0 0 4}$ | $\mathbf{2 0 0 5}$ | $\mathbf{2 0 0 6}$ | $\mathbf{2 0 0 7}$ | $\mathbf{2 0 0 8}$ | $\mathbf{2 0 0 9}$ | Total |
| :--- | :--- | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Celtic Sea | GNS VIlbcgik Dem |  |  |  |  |  |  | 3 | 3 |
|  | OTB VIlgfh Neph | 3 | 2 | 3 |  | 10 | 7 | 10 | 35 |
|  | OTB VIlj Neph | 3 | 2 | 2 |  |  | 1 | 1 | 9 |
|  | SSC VIIgj Dem | 3 | 5 | 3 |  | 4 | 3 | 4 | 22 |
|  | TBB VIlefgh Dem |  |  |  |  | 1 | 2 | 3 | 6 |
|  | OTB VIIfgjk Dem | 10 | 18 | 16 | 4 | 8 | 11 | 9 | 76 |

### 8.2.4.2 France

Data from the French onboard observer programme coordinated by IFREMER contribute to the characterization of fishing pressure at the community level by providing information about the catch composition, as well as the characteristics and conditions of the fishing operation (Fauconnet et al 2015).

According to the sampling plan of the national programme, observers randomly select professional fishing boats to embark on, and once aboard randomly sample fishing operations (FOs). A FO includes all actions from the shooting to the hauling of the gear. The geographical positions, target species, gear and mesh size used, fishing time, and other information on the fisher's strategy and conditions of the FOs are recorded. On sampled FOs, the whole catch is also recorded for both the landed and the discarded parts. All species of fish and commercial invertebrates are identified to the most precise level possible, ideally to the species level, counted, weighed (weight is sometimes calculated using the length/weight relationship) and measured. The level of species identification can vary according to the observer's experience and/or the species.

Distribution of observed fishing operations per metier is shown figure 1. Detail of representativeness of sampling per metier in term of vessels number, number of trips and days at sea can be found in annual restitution of the French observer at sea program, but it is generally very low in the same order of magnitude as Ireland (around 1\%).

### 8.2.4.2.1 Measuring Discards

During a typical catch sampling trip, data is collected on the gear type used, fishing ground, weather conditions, species catch composition and quantity of the landings and discards in the catch. Data on the length, weight and age composition of each discarded species is collected as well as length data for the landed species. A sample of discards (Dh), typically a 40 kg box, is randomly collected per haul andall fish species are identified and measured. The proportion of non-fish discards present in the box is alsorecorded. The total discards (D) for the haul are estimated by subtracting the total landings ( L ) from the total catch (C) for that haul.Total Discards (D) per haul = Total Catch (C) per haul - Total Landings per haul (H)The sample (Dh), is then raised up to total discards for that haul using the ratio of $\mathrm{D} / \mathrm{Dh}$. The total discards for the observed trip can then be estimated and further raised to fleet level.There are many different ways to raise catch data from the sampled level (i.e. an individual fishing trip) tofleet level (all trips).Data can be raised either using effort or total landings.
(i) Raising by effort: can be done in a number of ways for example hours fished, days fished and the number of trips carried out.
(ii) Raising by landings: can be done using total landings of all species or total landings of individualspecies.

Each of the different ways of raising the data will give different results depending on the appropriateness of the raising method used for a particular métier. The most appropriate method is one that reduces variability (error) in the data.

### 8.2.5 Methods for reducing discards

A series of gear based technical measures have been tested for reducing discards both in terms of total and relative (proportional) discarding. For the Irish side, these include cod end meshes (BIM 2015a), square mesh panels (BIM 2014), the use of grids in the Nephrops fisheries (BIM 2013), and twin and quad rigs in the Nephrops fishery (BIM 2015b). For the French side, these include separator panel on trawls targeting Nephrops (Charuau 1985, 1988), use of grids in trawls targeting anglerfish (Meillat et al 1993, 1994; Dupouy et al 2001). Selectivity trials are currently implemented as part of the CELSELECT projet (co founded by France Filière Pêche and Ifremer) lead by Ifremer Lorient . Devices tested are T90 codends, square mesh cylinder and grids.

Since 2012, a square mesh panel of 100 mm is mandatory for bottom trawlers and seines (TR1 and TR2 fleets) in area VIIf and $h$ and part of VII j (UE regultion N o $737 / 2012$ ). The mesh size of the square mesh panel has been increase to 120 mm early 2015 . Evaluation of the potential impacts of improving the selectivity patterns in the Celtic Sea on the catch advice for cod, haddock and whiting was conducted in 2014 (STECF, 2014).

### 8.2.6 Ecosystem modelling of the Celtic Sea

The Celtic Sea EwE model covers the ICES divisions VII f-g (approximately 222665 km², Figure 18: The Celtic Sea region).


Figure 18: The Celtic Sea region
The Ecopath model was constructed for the year 1991 (Lauria, 2012; Lauria et al, in prep). The model is composed of 64 functional groups including: 3 marine mammals, 6 seabird groups, 34 fish groups,

DiscardLess

15 invertebrates, 2 microbial groups, 1 primary producer (phytoplankton) and 3 detritus groups including: particulate organic matter, dissolved organic matter and discarded fish (Table 10).

Table 10: Functional groups in the Celtic Sea EwE model

|  | Marine mammals and seabirds |  | FG 34 | Rays and Skates |
| :---: | :---: | :---: | :---: | :---: |
|  | FG 1 | Baleen whales | FG 35 | Turbot and Brill |
|  | FG 2 | Toothed whales | FG 36 | Small and medium flatfish |
|  | FG 3 | Seals | FG 37 | Trisopterus spp. |
|  | FG 4 | Seabird offshore-surface feeders | FG 38 | Gurnards |
|  | FG 5 | Seabird inshore-divers | FG 39 | Pollack and Saithe |
|  | FG 6 | Seabird offshore-divers | FG 40 | Small benthic fish |
|  | FG 7 | Gulls | FG 41 | Small pelagic spp. |
|  | FG 8 | Manx shearwater | FG 42 | Garfish |
|  | FG 9 | European storm petrel | FG 43 | Demersal predators |
|  | Fish g | ups | Invert | groups |
|  | FG 10 | Cod | FG 44 | Small crabs and other decapods |
|  | FG 11 | Juvenile cod | FG 45 | Large crabs and lobsters |
|  | FG 12 | Blue whiting | FG 46 | Small crustaceans |
|  | FG 13 | Juvenile blue whiting | FG 47 | Bivalves |
|  | FG 14 | Hake | FG 48 | Gastropods |
|  | FG 15 | Juvenile hake | FG 49 | Cuttlefish |
|  | FG 16 | Plaice | FG 50 | Squid |
|  | FG 17 | Juvenile plaice | FG 51 | Sessile invertebrate |
|  | FG 18 | Megrim | FG 52 | Echinoderms |
|  | FG 19 | Juvenile megrim | FG 53 | Polychaetes |
|  | FG 20 | Whiting | FG 54 | Nematoda |
|  | FG 21 | Juvenile whiting | FG 55 | Zooplankton |
|  | FG 22 | Monkfish | FG 56 | Carnivorous macroplankton |
|  | FG 23 | Juvenile monkfish | FG 57 | Euphausiids |
|  | FG 24 | Haddock | FG 58 | Microflagellate |
|  | FG 25 | Juvenile haddock | Microb | oups and primary producers |
| International | FG 26 | Sole | FG 59 | Pelagic bacteria |
| and shellfish | FG 27 | Mackerel | FG 60 | Benthic bacteria |
| from <br> ICES | FG 28 | Horse mackerel | FG 61 | Phytoplankton |
| (ICES area VII | FG 29 | Red mullet | Detrit |  |
| and an average | FG 30 | Sea bass | FG 62 | Particulate organic matter |
| was calculated | FG 31 | Large sharks | FG 63 | Discards |
| country <br> (UK, | FG 32 | Small sharks | FG 64 | Dissolved organic matter |
| France, Spain, | FG 33 | Pelagic fish |  |  |

landings of fish were obtained Fishstat plus $\mathrm{f}-\mathrm{j}$ database from 1989-93 for each Ireland, Belgium, Germany and Netherlands). Unfortunately these data are not broken down into gear types, and for this reason all fishery landings were allocated to two gear types or fleets. Catches of pelagic schooling species
including Mackerel, horse mackerel, and clupeids were allocated to the pelagic fleet category. Landings of demersal fish including cod, hake, megrim, whiting, monkfish, haddock, red mullet, seabass, large sharks, turbot and brill, small and medium flatfish, trisopterus spp., and demersal predators were allocated to the demersal fleet. Commercially important crustacea, mollusca and cephalopods in the model (i.e. small crabs and other decapods, large crabs and lobster, bivalves, cuttlefish and squid) were also allocated to the demersal fleet. For each functional group landings were assigned and expresses as $\mathrm{t} / \mathrm{km}^{2}$.

Discards data were not available for the Celtic Sea, however for some groups they were calculated by using the rate of retains and discards available in the literature. In particular, the proportion of the total catch which is discarded was calculated as follows:

Discarded $(\mathrm{t})=$ landed $(\mathrm{t}) /$ landed $\% \mathrm{x}$ discarded \%
This formula was applied to each species for which data of discard rates existed. There is however a limitation in the utilization of this method, in particular the formula works on the basis that discards can be calculated as a proportion of the landings. This breaks down when $100 \%$ of a particular species are discarded, and there are no landings recorded.

### 8.2.7 References

Benoît, H. P., T. Hurlbut, et al. (2010). "Assessing the factors influencing discard mortality of demersal fishes using a semi-quantitative indicator of survival potential." Fisheries Research 106: 436447.

Benoît, H. P., T. Hurlbut, et al. (2012). "Estimating fishery-scale rates of discard mortality using conditional reasoning." Fisheries Research 125-126: 318-330.

Benoit, H. P., S. b. Plante, et al. (2013). "A comparative analysis of marine fish species susceptibilities to discard mortality: effects of environmental factors, individual traits, and phylogeny." ICES Journal of Marine Science: Journal du Conseil 70(1): 99-113.

BIM 2013 Summary of MFV Mater DeiTrials in the Irish Sea.BIM Gear Technology Report.
BIM. 2014. Assessment of a 300 mm square-mesh panel in the Irish Sea Nephrops fishery, BIM Gear Technology Report.

BIM 2015a Assessment of Diamond Cod-endMesh Size on Catch Composition ina Celtic Sea Nephrops Trawl Fishery.BIM Gear Technology Report.

BIM 2015b Catch comparison ofQuad and Twin-rig trawls in theCeltic Sea Nephrops fishery. BIM Gear Technology Report.

Borges, L., E. Rogan, et al. (2005).Discarding by the demersal fishery in the waters around Ireland. Fisheries Research (Amsterdam) 76(1): 1-13.

Breen, M. and R. Cook (2002).Inclusion of escape and discard mortality estimates in stock assessment models and its likely impact on fisheries management - A sensitivity analysis. ICES CM 2002/V:27

Charuau A (1985) Expérimentation d’un chalut séparant la langoustine (Nephrops norvegicus) du poisson. CIEM

Charuau A (1988) Compte-rendu de l'expérience sur le chalut "selectif" à langoustine à bord du RORQUAL II du 30 mai au 18 juin 1988. Ifremer, Lorient

Cornou Anne-Sophie, Dimeet Joel, Tetard Alain, Gaudou Olivier, Quinio-Scavinner Marion, Fauconnet Laurence, Dube Benoit, Rochet Marie-Joelle (2015). Observations à bord des navires de pêche professionnelle. Bilan de l'échantillonnage 2013. http://dx.doi.org/10.13155/35856

Cornou Anne-Sophie, Dimeet Joel, Tetard Alain, Gaudou Olivier, Dube Benoit, Fauconnet Laurence, Rochet Marie-Joelle (2013). Observations à bord des navires de pêche professionnelle. Bilan de l'échantillonnage 2012.

Davie, S. and Lordan, C. 2011. Definition, dynamics and stability of métiers in the Irish otter trawl fleet.Fisheries Research 111(3): 145-158

Dupouy H, Meillat M, Kergoat B, Rivoalen J-J (2001) Une solution à la mésexploitation des espèces benthiques : le chalut à grille sélective pour la protection des juvéniles d'espèces benthiques. Ifremer, Lorient

Enever, R., T. L. Catchpole, et al. (2009). "The survival of skates (Rajidae) caught by demersal trawlers fishing in UK waters." Fisheries Research (Amsterdam) 97(1-2): 72-76.

Fauconnet Laurence, Trenkel Verena M., Morandeau Gilles, Caill-Milly Nathalie, Rochet Marie-Joelle (2015). Characterizing catches taken by different gears as a step towards evaluating fishing pressure on fish communities. Fisheries Research, 164, 238-248.

Heath, M. R., R. M. Cook, et al. (2014). "Cascading ecological effects of eliminating fishery discards." Nature Communications NATURE COMMUNICATIONS | 5:3893| DOI: 10.1038/ncomms4893 |www.nature.com/naturecommunications

Ingo'lfsson, O' . A., Soldal, A. V., Huse, I., and Breen, M. 2007. Escape mortality of cod, saithe, and haddock in a Barents Sea trawl fishery. - ICESJournal of Marine Science, 64: 1836-1844.

Lauria V, (2012). Impacts of climate change and fisheries on the Celtic Sea ecosystem. PhD thesis, Plymouth University, Plymouth, UK, 226 pp."

Lauria V, Mackinson S, Pinnegar JK, in prep. An ecopath model for the Celtic Sea: ecosystem properties and sensitivity analysis.

Meillat M, Dupouy H, Bavouzet G, George JP, Vacherot J-P, Morandeau F, Kergoat B (1993) Compterendu de mission. Coopération DRV/RH - DITI/NPA Lorient. Campagne technologie 93. Essai d'un chalut sélectif pour la baudroie. N/O Gwen Drez du 14/06 au 7/07/93. Ifremer, Lorient

Meillat M, Dupouy H, Bavouzet G, Vacherot J-P, Morandeau F, Kergoat B, Gaudou 0 (1994) Le chalut sélectif à baudroies. Compte-rendu de mission N/O Gwen Drez. Coopération DRV/RH DITI/GO/NPA Lorient. Campagne SELECT 4 du 17/03 au 30/03/94. Bilan d'une année de travail et de trois campagnes à la mer. Ifremer, Plouzané

Revill, A. S., N. K. Dulvy, et al. (2005). The survival of discarded lesser-spotted dogfish (Scyliorhinuscanicula) in the Western English Channel beam trawl fishery. Fisheries Research (Amsterdam) 71(1): 121-124.

Rochet, M. J., I. Peronnet, et al. (2002). An analysis of discards from the French trawler fleet in the Celtic Sea. ICES Journal of Marine Science 59(3): 538-552.

STECF 2014. 47th PLENARY MEETING REPORTOF THE SCIENTIFIC, TECHNICALAND ECONOMIC COMMITTEE FOR FISHERIES (PLEN-14-03), Chapter : 6.1. Selectivity in the Celtic Sea (p38).

Viana, M., L. McNally, et al. (2014). "Ignoring discards biases the assessment of fisheries' ecological fingerprint." Biology Letters 9(6).

