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DISCARDED MACKEREL IN SPANISH FISHERIES (ICES Divisions Via-b, VIIb-c-g-h-j-k, VIIIc, IXaN and IXaS)

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Material and methods

Sampling strategy

The sampling strategy and the estimation methodology used in the “Spanish Discards Sampling Programme” has been little modified since 1994, and since 2003 follows the guidelines established by ICES (ICES, 2003) and raising procedure is based in ICES, 2007.

The observers-on-board programme is based on a hierarchical sampling design, applied to strata defined by two dimensions. Year was considered the strata unit for the temporal dimension until 2009, when the DCF asked for quarterly estimates. Herein results from 2012 are organised and presented at quarterly basis. The second sampling dimension is technical, and the strata unit is the Métier. In regards to the sampling units, trips (the Primary Sampling Unit [PSU]) are randomly or quasi-randomly selected from the bidimensional strata. Once onboard, the observer systematically select hauls for sampling, (the Secondary Sampling Unit [SSU]) when the total number of hauls is expected to be high during the sampled trip; otherwise, all hauls are sampled. The Ultimate Sampled Unit (USU) is the numbers of individuals by species found in discard sample.

Only trawl fleet and purse seiner fleet from IXaS zone information are used in this document. Other fleets (i.e. long line or purse seine fleet in northern VIIIc and IXaN) were evaluated, showing very low discards along the areas under study (Pérez et al., 1996). Gillnet discard information is being obtained since 2008, but the time series available has been considered too short to be presented in the present document.

Discard value are estimated per métier and Divisions (VIIb, Divisions VIIIc-j, Division VIIIk, Division VIIIc, Sub-Division IXaN and Sub-Division IXaS) separately. Fishing area, gear and target species are the auxiliary covariates used to stratify fleets into métiers. Two Spanish trawl métiers are defined in the ICES Subareas VI and VII (Bellido and Pérez, 2007):

- OTB_DEF_70-99_0_0 trips targeting Megrim, Monk and Hake
- OTB_DEF_100-119_0_0 trips targeting Hake and Monk

More complex structure is found for the Spanish trawl fleet operating in ICES Divisions VIIIc and IXa North:

- OTB DEF>=55_0_0: trips targeting a mixed of demersal species using conventional OTB gears
- OTB_MPD>=55_0_0: trips targeting a mixed of pelagic and demersal species using high vertical opening OTB gears

- PTB DEF >=55_0_0: trips targeting demersal species using bottom pair trawls
- Finally, only two métiers were defined for the ICES Division IXa South:
- OTB MCD >=55_0_0: trips targeting demersal species using bottom pair trawls
- PS_SPF_0_0_0: trips targeting sardine using purse seiner

Discard estimates by métier have been aggregated into fishing ground level, in order to present total discards by the whole Spanish trawl fleets.

Sampling scheme & Raising procedures

Estimates of the discard weight was calculated from length distribution using length-weight relationships and raised to the total discard by trip. The haul-raised data were further raised to total hauls in the trip (total hauls in trip/sampled hauls in trip).

From the two methods to raising discards considered, a ratio estimator and a simple estimator (Borges, 2005; ICES, 2007), a simple estimator, number of fishing trips, was chosen for raising procedure based on the accuracy they might give and also on their availability.

Quantification of discards

For each haul an estimate of the total catch is made in kilograms, based on the total volume of the bottom trawl codend by the skipper or a crew member based on the amount of the fish in the hopper tank. The catch is sorted into species by the crew along a conveyor. The retained fish is saved and sorted into fish boxes. Several species (hake, monkfish) can be graded by sizes and some gutted. The observer samples lengths of the retained fish.

Total retained catch is calculated by a census of fish boxes and multiplying by the mean weight of an individual species commercial box. Total discards for the haul are estimated by the skipper taking into account the retained fish and the amount of the gear codend.

The crew fills one or more baskets of discards by collecting the species (all species of fish and invertebrates) before they would be dumped out to the sea by the conveyor belt. A sample of around 20 kg, depending of the size of discarded species, is collected. The discard sample is weighed by the observer using a balance.

All fish species of the discard sample are sorted and identified to species level or to genus-family level. All fish, and Nephrops crustacean, in the sample are measured for length (a subsample is made when there are large numbers of small species).

For mackerel, numbers at length were converted to age classes using ALK's obtained at the biological sampling programme (basis, half year) split in IXaN + VIIIc-West, VIIIc-East and VIIIab. For northern areas, ALK's from VIIIab were used

Results

During 2012 the discard sampling programme has covered more than 75% of the Spanish trawling fishing effort, except that exerted by the OTB_DEF_100_119_0_0 métier, to which the sampling programme covered only the 28% of the fleet effort, although the discard level for this métier is low. This métier is restricted to deeper water around the slope and the towing speed is slower and makes about 7 hour hauls (table 1).

Table 1a: Relative fishing effort in northern waters by metier and quarter exerted by the Spanish trawling fleets. Those quarters and divisions with white blue background were not covered by the discard sampling programme

OTB_DEF_100_119_0_0					
Trips	1st Q	2nd Q	3rd Q	4th Q	
Division VIa	2.0	11.6	1.8	0.3	
Division VIb	0.0	0.0	0.5	0.0	
Division VIIb	0.5	2.0	1.0	0.0	
División VIIc	3.3	6.8	5.8	2.8	
División VIIg	0.0	0.0	0.0	0.0	
División VIIh	0.0	0.0	0.0	0.0	
División VIIj	8.4	12.7	7.8	14.7	
División VIIk	6.6	0.0	4.6	6.8	

OTB_DEF_70_99_0_0					
Trips	1st Q	2nd Q	3rd Q	4th Q	
Division VIa	0.0	0.0	0.1	0.0	
Division VIb	0.1	0.0	0.0	1.2	
Division VIIb	0.7	0.4	0.1	3.2	
División VIIc	2.1	2.1	1.9	3.5	
División VIIg	4.1	3.1	1.4	2.3	
División VIIh	5.0	4.9	2.8	2.6	
División VIIj	14.7	11.8	11.7	16.0	
División VIIk	0.8	1.3	1.1	1.1	

Table 1b: Relative fishing effort in Iberian waters by metier and quarter exerted by the Spanish trawling fleets. Those quarters and divisions with white blue background were not covered by the discard sampling programme

OTB_DEF_>=55_0_0					
Trips	1st Q	2nd Q	3rd Q	4th Q	
VIIIc	16.1	17.3	21.5	16.7	
IXa N	7.8	5.9	6.2	8.5	

OTB_MPD_>=55_0_0					
Trips	1st Q	2nd Q	3rd Q	4th Q	
IXa N	8.2	6.8	10.2	6.8	
VIIIc	23.9	21.4	12.5	10.3	

PTB_MPD_>=55_0_0					
Trips	1st Q	2nd Q	3rd Q	4th Q	
VIIIc	29.3	21.7	25.1	23.9	

OTB_DES_>=55_0_0					
Trips	1st Q	2nd Q	3rd Q	4th Q	
IXa S	26.8	30.7	25.8	16.7	

PS_SPF_0_0_0					
Trips	1st Q	2nd Q	3rd Q	4th Q	
IXa S	10.3	33.5	45.7	10.5	

In northern areas (Divisions VIa, VIb, VIIb, VIIc, VIIg, VIIh, VIIj and VIIk) a total of 339 hauls, corresponding to 11 trips, were sampled (93% for OTB_DEF_70_99_0_0) whilst 167 trips sampled in Iberian waters (VIIIc, IXaN and IXaS); in this case, roughly each trip correspond to a one working day (table 2)

Table 2a: Number of hauls sampled in northern waters by metier and quarter. Those quarters and divisions with white blue background denotes divisions and quarters with fishing activity not covered by the discard sampling programme

OTB_DEF_100_119_0_0				
Hauls	1st Q	2nd Q	3rd Q	4th Q
Division VIa				
Division VIb	0	0		0
Division VIIb				0
División VIIc				
División VIIg	0	0	0	0
División VIIh	0	0	0	0
División VIIj				7
División VIIk	14	0		4

OTB_DEF_70_99_0_0				
Hauls	1st Q	2nd Q	3rd Q	4th Q
Division VIa	0	0		0
Division VIb		0	0	
Division VIIb				0
División VIIc				6
División VIIg	5	18		
División VIIh	18	3		28
División VIIj	111	58	34	31
División VIIk				2

Table 2b: Number of trips (days) sampled in Iberian waters by metier and quarter. Those quarters and divisions with white blue background denotes divisions and quarters with fishing activity not covered by the discard sampling programme

OTB_DEF_>=55_0_0				
Trips	1st Q	2nd Q	3rd Q	4th Q
VIIIc	10	13	14	9
IXa N	3	4	7	4

OTB_MPD_>=55_0_0				
Trips	1st Q	2nd Q	3rd Q	4th Q
IXa N	2	2	1	
VIIIc	11	8	4	5

PTB_MPD_>=55_0_0				
Trips	1st Q	2nd Q	3rd Q	4th Q
VIIIc	8	8	5	9

OTB_DES_>=55_0_0				
Trips	1st Q	2nd Q	3rd Q	4th Q
IXa S	7	13	7	9

PS_SPF_0_0_0				
Trips	1st Q	2nd Q	3rd Q	4th Q
IXa S		3	1	

In Iberian waters, the sampling effort matches quite well with the fishing effort (differences in relative effort were lower than a 9%), whilst in northern waters the first quarter of VIIj Division has been oversampled (16%) but the fourth quarter was undersampled by a 10%.

Mackerel discards in 2012

An estimation of 3.811,4 mt of mackerel were discarded during 2012 in northern waters, most of them during the first quarter (77%). 91.3% of the mackerel discarded was located in VIIj. In northern Spanish waters (VIIIc and IXaN) a total of 2.209,2 mt were discarded, (99% in VIIIc) as in the case of northern areas 83,3% were taken during the first quarter. Complementary, in IXaS discards mainly occurred during the second half of the year (81% of a total of 870 mt), most of them specifically during the third quarter (64%) (table 3).

Table 3: Mackerel discard estimates by ICES divisions and quarter in metric tonnes (sampled discards raised to the total fishing effort)

Quarter	Via	Vib	VIIb	VIIc	VIIg	VIIh	VIIj	VIIk	VIIIc	IXaN	IXaS
1 st	na	Esf. 0	na	0.8	21.7	289.8	2609.1	0.0	1820.2	21.7	26.4
2 nd	na	Esf. 0	na	1.6	0.0	14.4	735.3	0.0	64.9	0.0	135.9
3 rd	na	na	na	1.4	0.0	0.0	68.0	0.0	279.3	0.0	553.3
4 th	na	na	Esf. 0	0.6	0.0	0.0	68.8	0.0	23.1	0.0	153.9
Total	na	na	na	4.4	21.7	304.2	3481.2	0.0	2187.5	21.7	869.5

Discard estimates by age group in northern areas:

Discards by age group are shown in figure 1

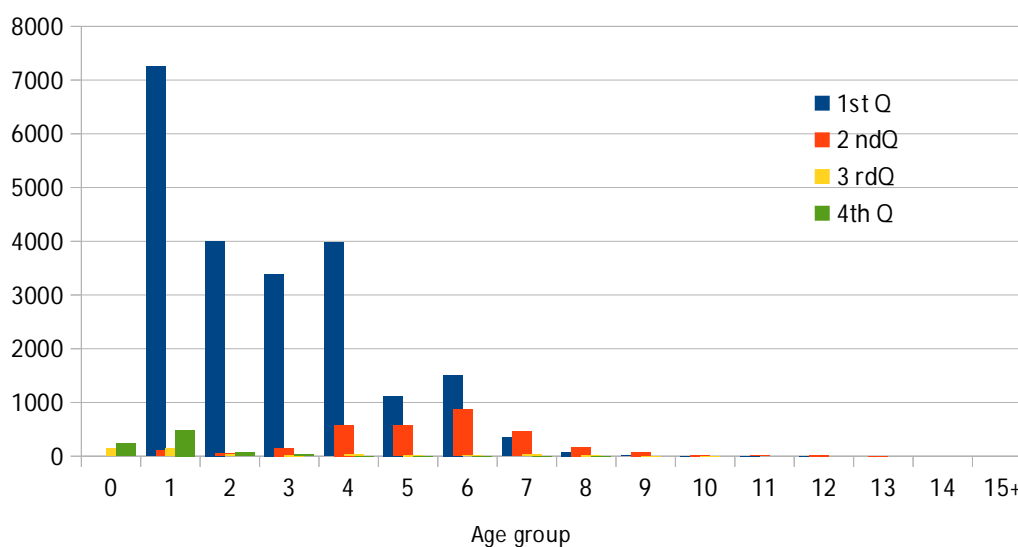


Figure 1: Discard estimates (thousands) by age group and quarter in northern waters (VI and VII divisions) in 2012.

Most of the discards occurred during the first quarter, mainly composed by young fish (mean length of 26.9); this pattern is different to that found in the second quarter in which adult fish are mainly discarded (age groups 4 to 9 and mean length of 34.6 cm). During the second half of the year, discards are negligible, and most of them came from younger fish (75% belonging to

age groups 0 to 3). Comparing with results achieved by the Dutch fleet (Borges et al., 2008), Spanish discards could have higher size than those of the Dutch freezer-trawler fleet.

Discard estimates by age group in north Iberian Peninsula (VIIIc and IXaN):

Discards by age group in VIIIc are shown in figure 2

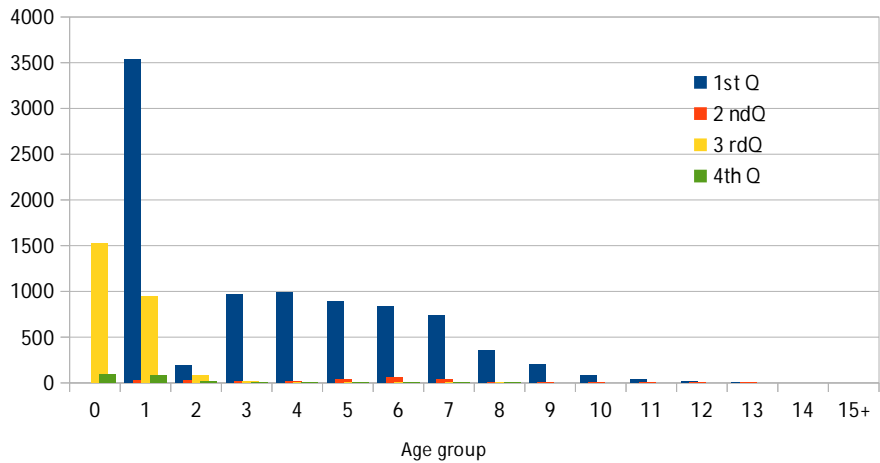


Figure 2: Discard estimates (thousands) by age group and quarter in VIIIc Division in 2012.

Most of the discards occurred during the first quarter (75%), mainly composed by young fish (53% belonging to age group 3 or younger). Besides, during the third quarter the number of discards increased being almost all of them for ages groups 0 and 1. During the second and fourth quarter discards were almost negligible. Comparing the relative age composition in both discards and landings, the differences in age distribution are significant (maximum difference in cumulative relative age distribution was 0.51, higher than the Kolmogorov-Smirnoff statistic), but landings and catch are almost the same age frequency distribution (maximum difference in cumulative relative age distribution was 0.07, lower than the Kolmogorov-Smirnoff statistic)

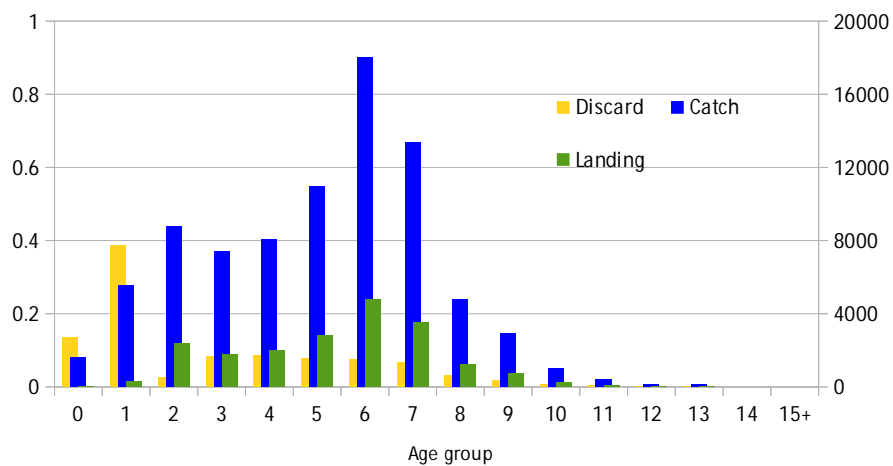


Figure 3: Relative comparison between year landing and discard (main Y axis) and catch in number (secondary Y axis, number in thousands) in VIIIc Division in 2012.

Discard by age group in IXaN are shown in figure 4

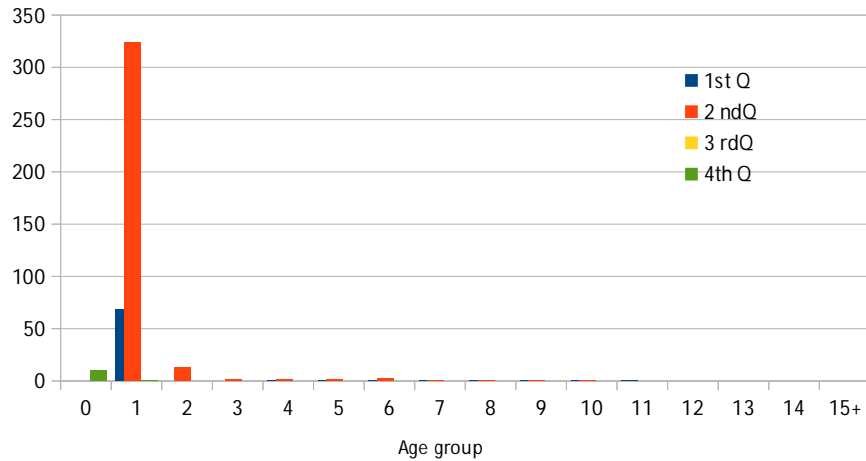


Figure 4: Discard estimates (thousands) by age group and quarter in IXaN Division in 2012.

Contrary to that observed in VIIIc, in IXaN most of the discard took place during the second quarter and during the third one, no discard was estimated. Moreover, only juveniles (age group 1 during the first and second quarter and age group 0 during the fourth) were discarded. Also the differences between age composition in discard and landing are much higher than that observed in VIIIc, and this resulted also in significant differences in age distribution between catch and landing (maximum difference in cumulative relative age distribution were 0.70 and 0.93 for, respectively, landing and discard comparison and catch and landing)

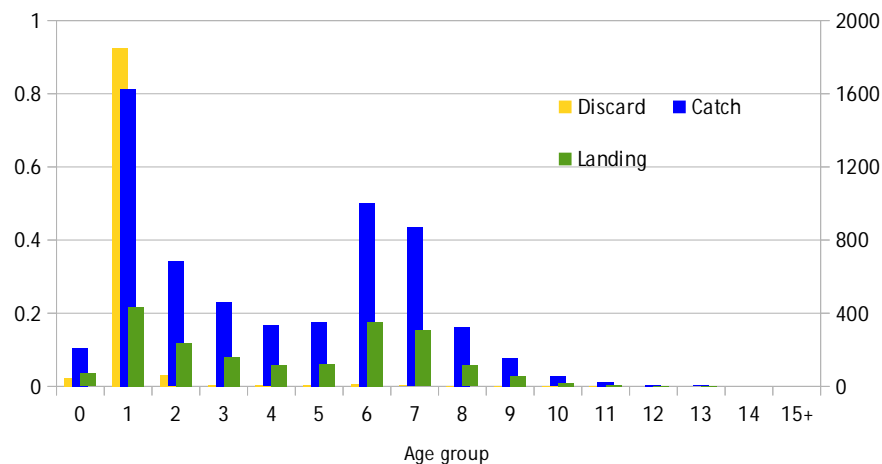


Figure 5: Relative comparison between year landing and discard (main Y axis) and catch in number (secondary Y axis, number in thousands) in IXaN Division in 2012.

In north Spain (VIIIc and IXaN), discards represent less than a 10% of the total catch. There was almost no discards during second half of the year (figure 6ab).

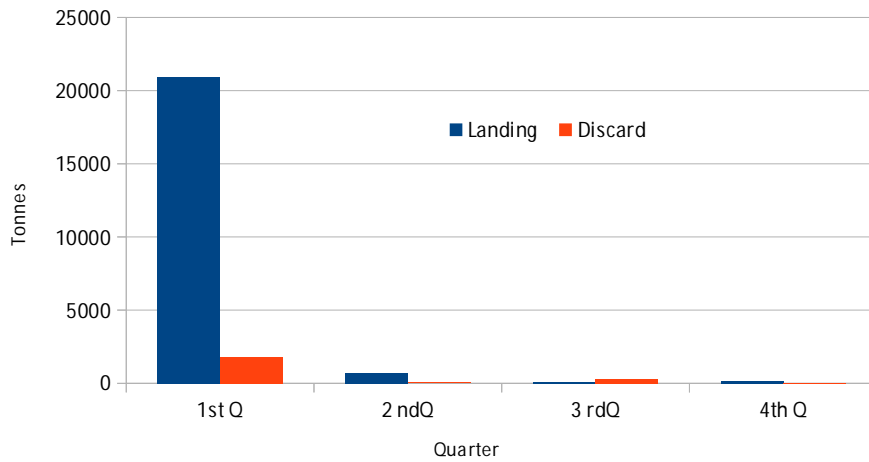


Figure 6a: Discard and landing estimates (tonnes) by quarter in VIIIc Division in 2012.

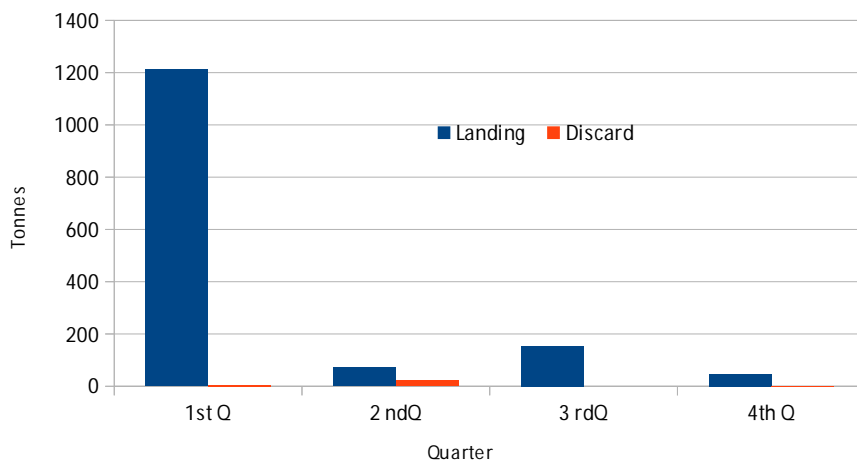


Figure 6b: Discard and landing estimates (tonnes) by quarter in IXaN Division in 2012.

Discard estimates by age group in south Iberian Peninsula (IXaS):

Due to difficult in ALK, discard estimates by age group in south Iberian Peninsula (IXaS) was not available.

As expected, discards in the Gulf of Cadiz are relatively important and much higher than landing (a 67% of the total catch) and most of them occurred during the second half of the year (figure 7)

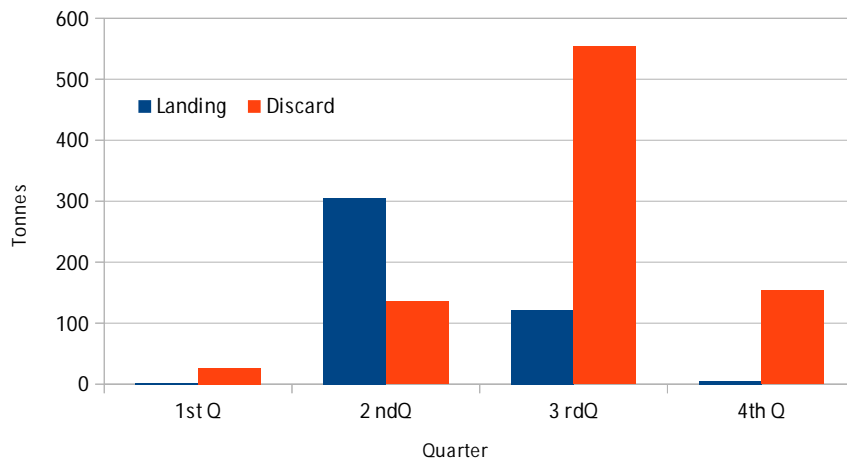


Figure 7: Discard and landing estimates (tonnes) by quarter in IXaS Division in 2012.

Discard time series

The time series analysed in this document started in 2003. (figure 8). Discarded mackerel in the analysed regions didn't show a defined trend, alternating years with highest discarded values in northern with other in which the bulk of discarded mackerel occurred in north Iberian waters.

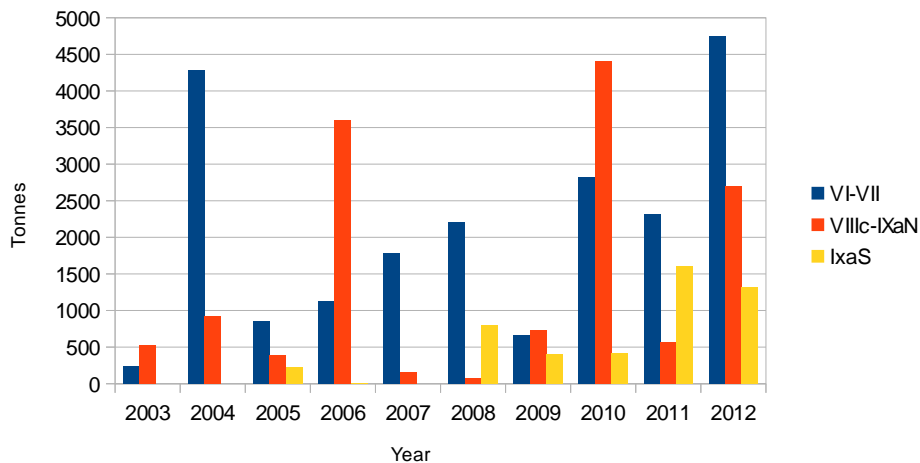


Figure 8: Discard estimates (tonnes) by year and Division since 2003.

Most of the discard in northern area (VI and VII) were taken by the metier targeting in megrim (OTB_DEF_70-99_0_0); only in 2011 discard for metier targeting in hake and monkfish (OTB_DEF_100-119_0_0) were relevant as shown in figure 9

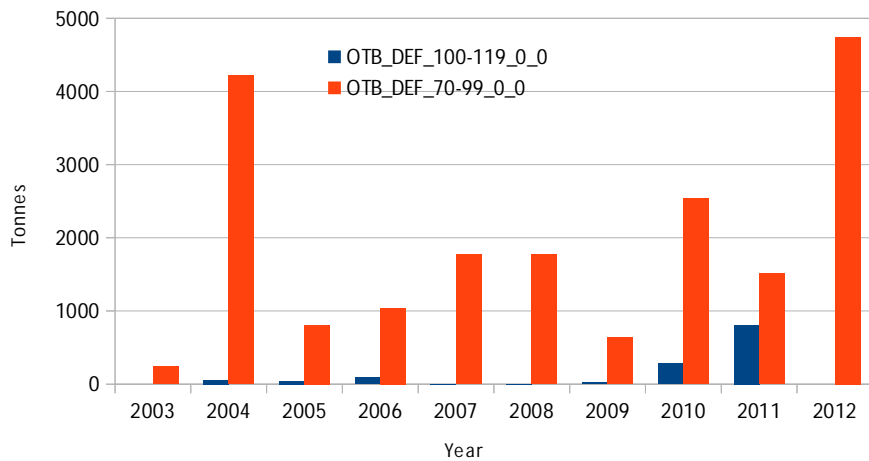


Figure 9: Discard by métier and year in northern area (Divisions VI and VII)

Age composition along time series did not show any particular pattern, but in weight, most of them are composed by adult fish except the proportion occurred in 2006, 2008 and 2011 (figure 10)

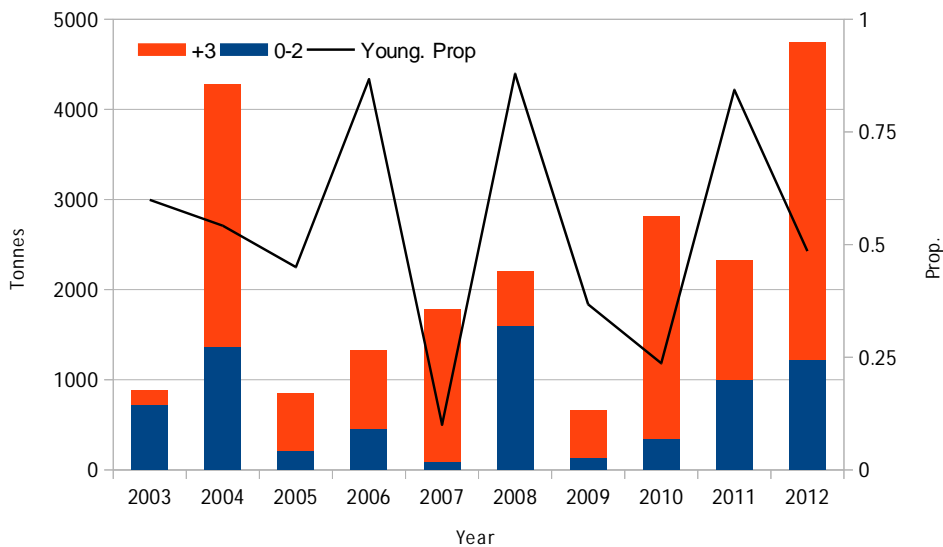


Figure 10: Discard proportion (tonnes) between younger mackerel (0-2 age groups) and adults (+3) since 2003. Right Y axis shows the proportion in number of younger mackerel (Divisions VI and VII)

In north Iberian Peninsula, there was a change in 2006 when the métier targeting in mixed pelagic and demersal species, took more discard than that of the targeting in demersal species one (figure 11).

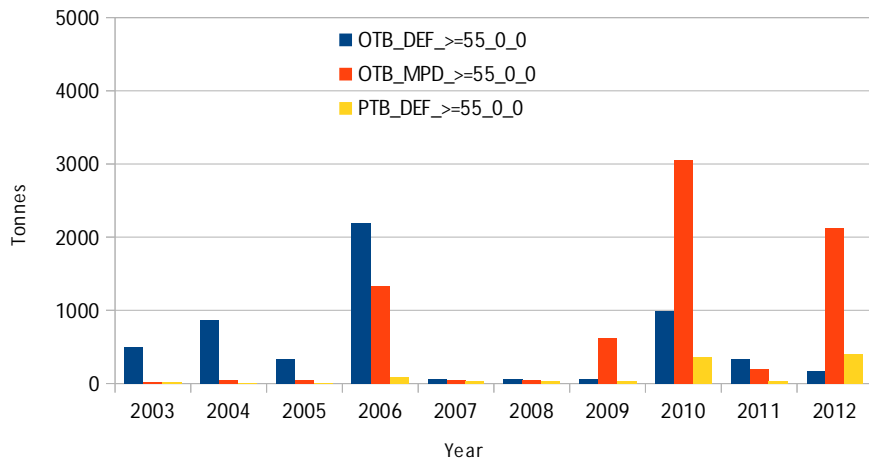


Figure 11: Discard by métier and year in north Iberian Peninsula (Divisions VIIIc and IXaN)

In this case, most of the mackerel discard belonged to age group 2 and younger (figure 12), achieving up to 99%.

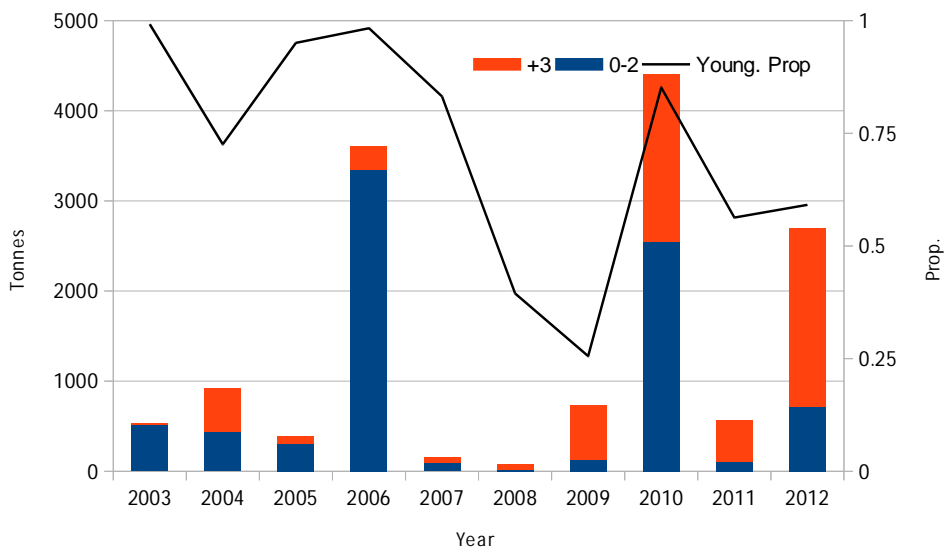


Figure 12: Discard proportion (tonnes) between younger mackerel (0-2 age groups) and adults (+3) since 2003. Right Y axis shows the proportion in number of younger mackerel (Divisions VIIIc and IXaN)

In the Gulf of Cadiz, purse seiner métier was also analysed, and most of the discard were taken by this métier, as shown in figure 13

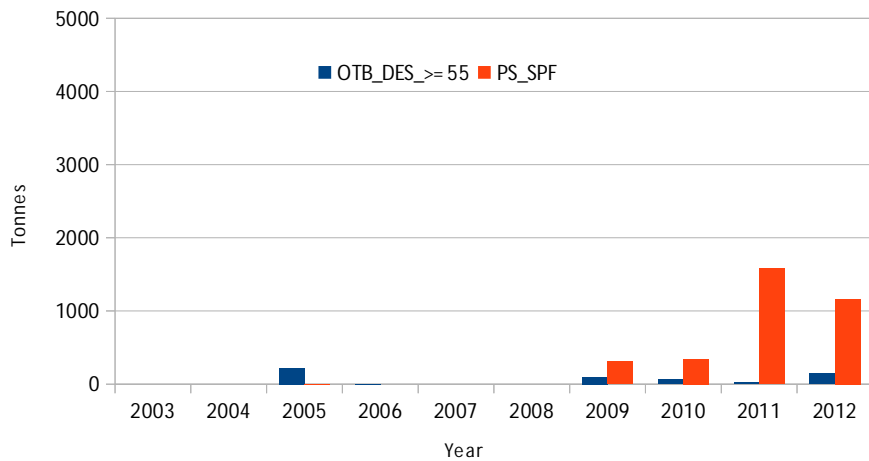


Figure 13: Discard by metier and year in south Iberian Peninsula (Division IXaS)

Precision

CV's by half year and metier are shown in figure 14a-d. These were calculated for mackerel discards in number. No clear relation between sampling effort (no of trips) and cv's could be inferred since precision is calculated on species basis, thus depending on other factors such as relative abundance (compared with the target fishing species), mackerel size (i.e. recruitment strength) among other factors, but in general these are similar to that calculated for the Dutch pelagic freeze-trawler fleet between 2002 and 2005. (82.1 in number and 39.1 in biomass, Borges et al, 2008).

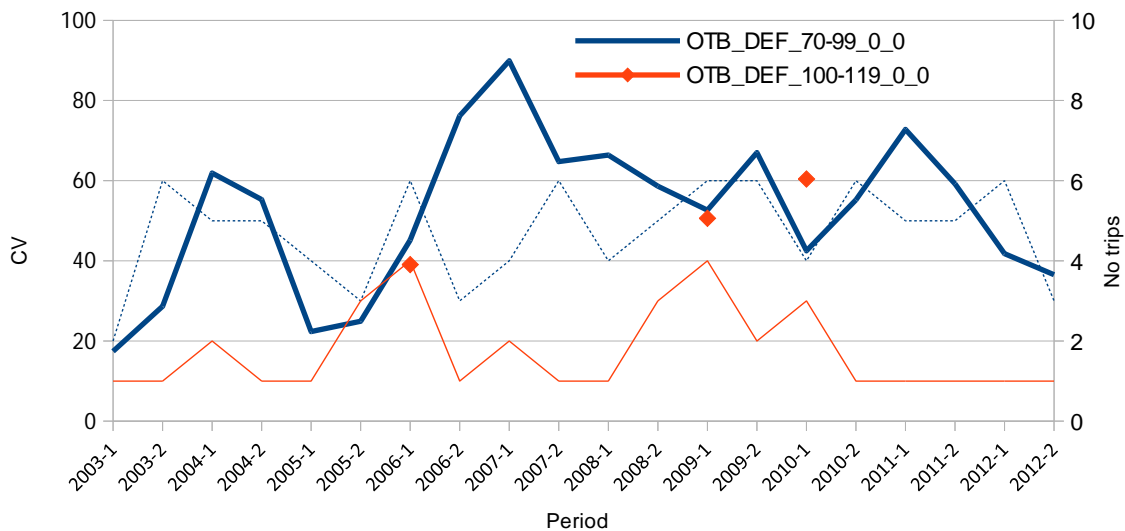


Figure 14a: CV (left axis, thick line) and number of trips sampled (right axis, dashed line) by metier and half year in northern area (Divisions VI and VII)

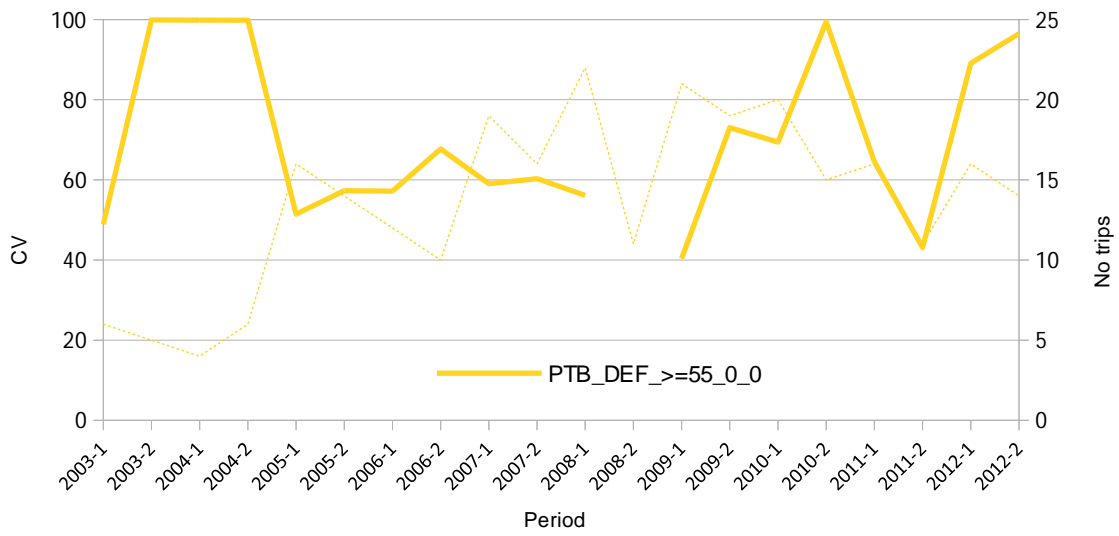


Figure 14b: CV (left axis, thick line) and number of trips sampled (right axis, dashed line) by metier and half year in north Iberian Peninsula (Divisions VIIIc and IXaN)

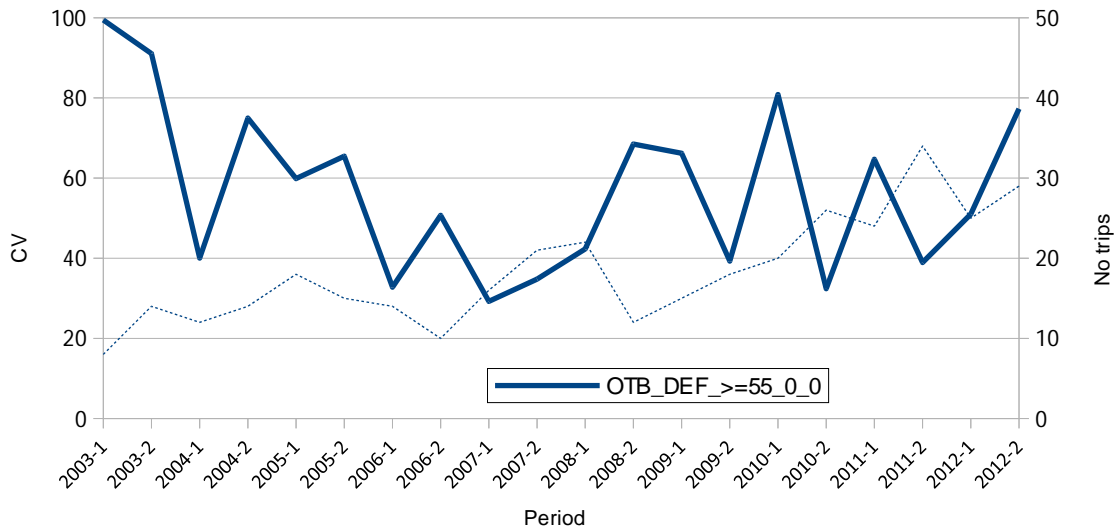


Figure 14c: CV (left axis, thick line) and number of trips sampled (right axis, dashed line) by metier and half year in north Iberian Peninsula (Divisions VIIIc and IXaN)

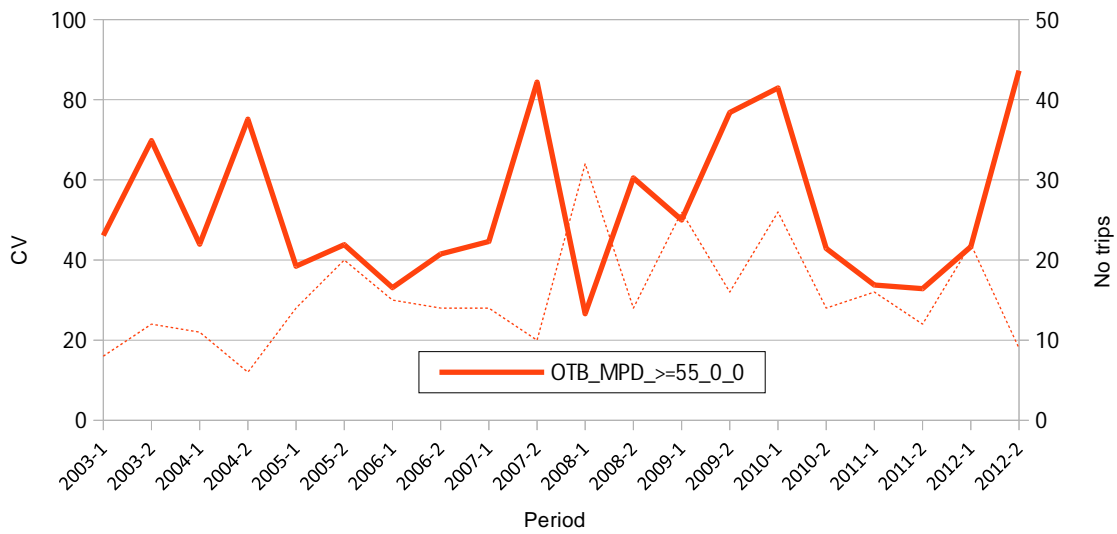


Figure 14c: CV (left axis, thick line) and number of trips sampled (right axis, dashed line) by metier and half year in north Iberian Peninsula (Divisions VIIIc and IXaN)

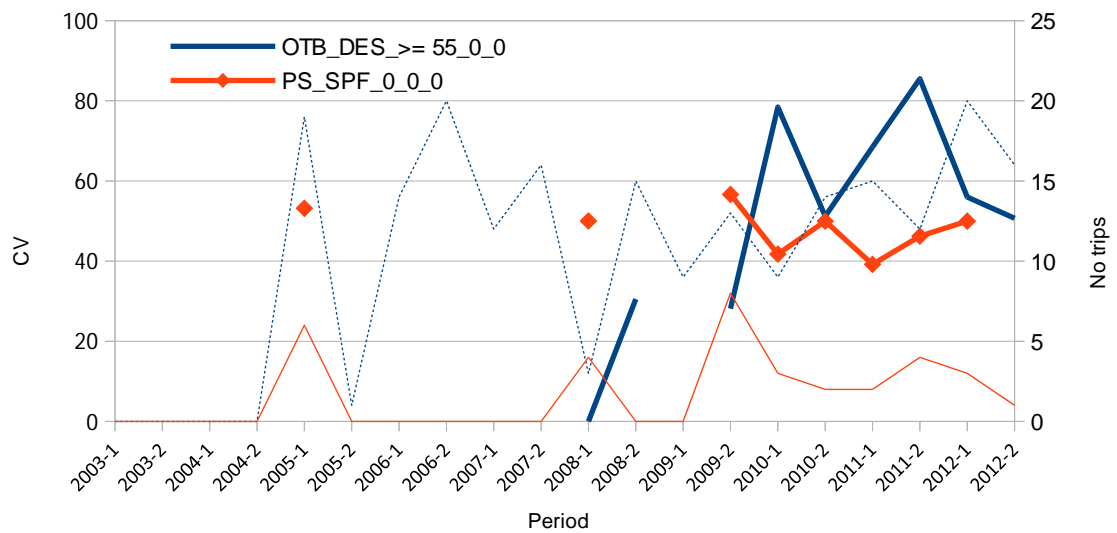


Figure 14d: CV (left axis, thick line) and number of trips sampled (right axis, dashed line) by metier and half year in south Iberian Peninsula (Gulf of Cadiz, Division IXaS)

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