Ref. Ares(2019)2387732 - 04/04/2019

Informe Técnico del Instituto Español de Oceanografía (IEO)

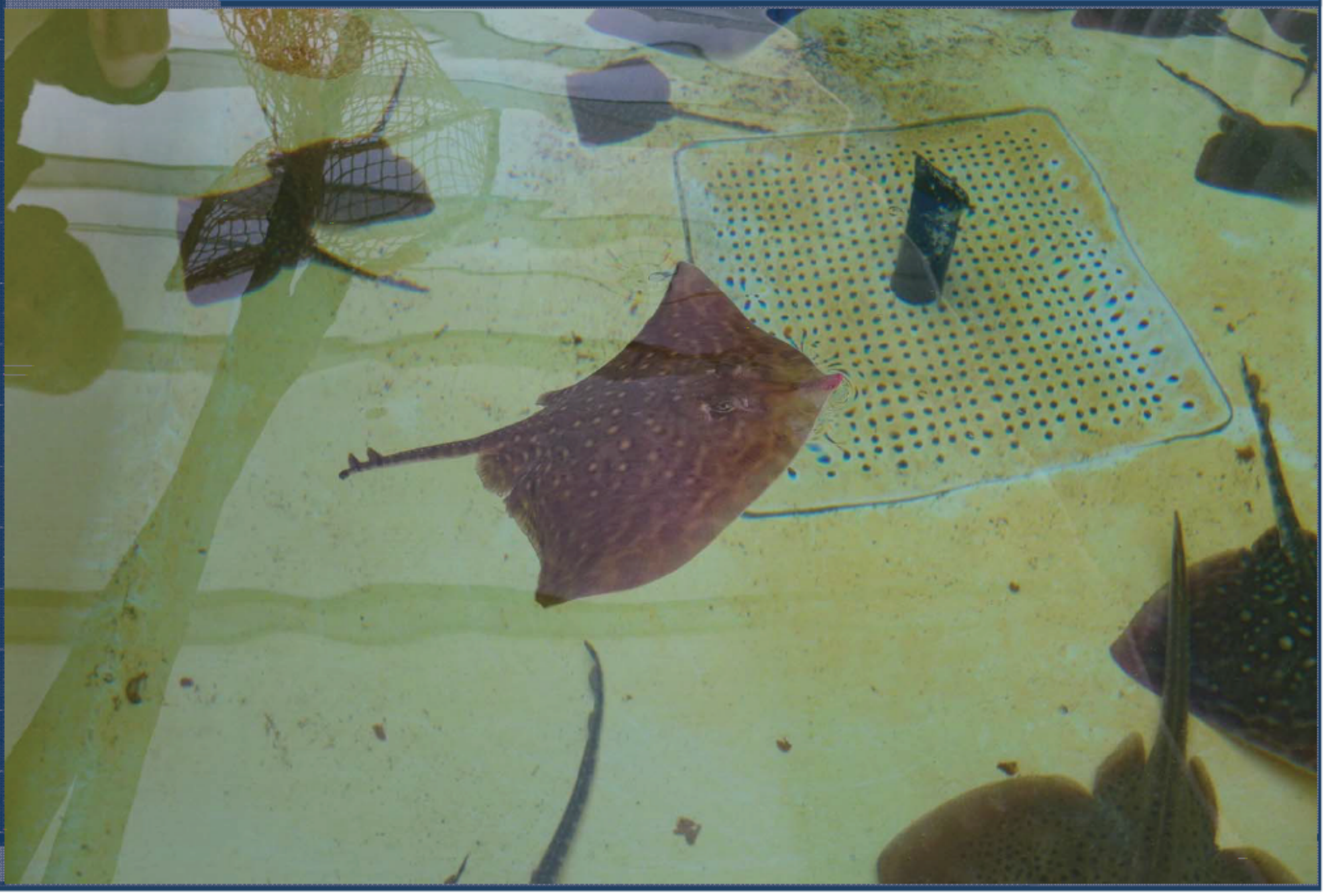
PROYECTO DESCARSEL

Discard reduction strategies in Spanish fisheries

Project DESCARSEL

Technical Report of Study on survivability of rays and skates in fisheries at north Spanish fishing ground ICES 8c and 9a.

Autors: [redacted]



Acknowledgments:

In the development of this studies have involved a large number of people and it has been essential the participation of [redacted] and crew of the fishing ship [redacted] (Federación Galega de Cofrarías de Pesca), [redacted] and crew of the fishing ship [redacted], [redacted] (OPROMAR-Marín), M[redacted] (Xunta de Galicia), [redacted], staff of the plant of culture of the IEO of Vigo and personnel of security. [redacted] (CEFAS), [redacted] and [redacted] (ILVO) helped us in the analysis of results. [redacted] helped us during all the study (MAPAMA-Secretaria General de Pesca). To all of them we want to express our gratitude.

Project support by:

This study was carried out as part of DESCARSEL Project. The DESCARSEL project is a IEO-funded project that works on the updated analysis of fishing strategies, gear selectivity and discard survival through the use of better practices and technological development of more selective fishing gear or devices, for the compliance of the landing obligation of the new reform of the CFP in the coming years. Research studies uses a collaborative approach, working with Fishermen associations and the stakeholders related to landing obligation normative.

The IEO has been carrying out different research projects with national and international funding, aimed at the scientific analysis of the characteristics of discards by fishery, its impact on stocks and ecosystems and mitigation measures and reduction of fishing discards through operational, technical and socioeconomic measures.

UNIÓN EUROPEA

FONDO EUROPEO MARÍTIMO Y DE PESCA (FEMP)

GOBIERNO DE ESPAÑA

MINISTERIO DE AGRICULTURA, ALIMENTACIÓN Y MEDIO AMBIENTE

This document should be cited as follows:

[redacted] 2018. Technical Report of survey DESCARSEL0318: Study of discard and unwanted catch reduction strategies. Survivability of rays and skates in the otter bottom trawl fishery at Spanish fishing ground 'Cantábrico-noroeste'.

Contact autors: [redacted]

Centro Oceanográfico de Vigo. Instituto Español de Oceanografía (IEO). Subida a Radio Faro, 50. 36390 Vigo (Spain)

Version: 25 Mayo 2018

EXECUTIVE SUMMARY

- Article 15 of the new CFP establishes the "landing obligation", and includes several exemptions and flexibility tools. One exemption from the landing obligation is described for “species for which scientific evidence demonstrates high survival rates, taking into account the characteristics of the gear, of the fishing practices and of the ecosystem”.
- There is a perception by the fishermen of some species that could have a high survival rate in these fisheries, which could be returned alive to the sea avoiding the obligation to take them to port and thereby endanger fishing quotas with a premature closure of the fishery. The exemptions and flexibilities referred to in Article 15 of the CFP must be justified and supported by ad hoc scientific studies.
- This report presents the results of two research trials on discard survival rates of rays caught in commercial fisheries in north Spanish waters: ray discard survival at bottom trawling fishing and at trammel fishing.
- The selected approach was to carry out vitality assessments at sea during normal fishing activity and a long-term captive observation experiment.
- A proportion of 93.46% and 100% of discarded rays assessed for vitality in bottom trawling and trammel nets survive to fishing operations and handling onboard.
- *Raja clavata* scored the lower survivability (58%-100%), *Raja montagui* intermediate (100%) and all specimens of *Raja undulata* survived the 36 hours first phase trial without mortality events (100% survivability).
- In bottom trawler the estimated survival at 36h was 58% (47.7-69.9)
- In trammel net the estimated survival at 48h was 95.5% (87.1-100)
- The highest proportion of dead and poor health status was in bottom trawling trial. Results indicate differences in survival between the health status of rays.
- Many factors influence survival and some of them are poorly understood and difficult to control across species, fisheries and areas: characteristics of the fishing haul (time, depth, speed, gear…), composition and volume of fish in the codend, time of capture in the fish, time of hauling onboard, handling by fishers, method of discarding, biology of species, etc.
- Several factors influence survival experiments, including the transport and captivity onshore of the fish.
- Long-term survivability in *Raja clavata* was 17% (10.1-27.4) at the end of the observed period (one month). Stress and conditions at captivity should be a factor to take into account in this study and to analyze in future works. Most of the thornback rays did not feed till 3 weeks at captivity.
- It is planned several workshops and dissemination of results to the fishing sector to advise them and encourage fishermen to good fishing discarding practices and involvement in research trials. The project DESCARSEL and stakeholders will produce a 'Guidelines of best practices: handling, maintenance and release of discarded rays'.
- The results presented here shows survivability of caught skates at short-term for both fisheries. Also, the survivability in net fishery results very high. These fisheries could be candidates to apply the High Survivability Exemption taking into consideration the provision detailed in Article 15 of Regulation (EU) No 1380/2013 paragraph 4(b), exemptions to the landing obligation can be obtained for species in which “scientific evidence demonstrates high survival rates, taking into account the characteristics of the gear, of the fishing practices and of the ecosystem.

1. INTRODUCTION

The European Commission has set a series of objectives in relation to the reduction of fishing discards that will be implemented in the very near future. The Commission considers it important that the challenge of reducing discards be raised in a responsible manner to ensure the current profitability of fishing. The new Common Fisheries Policy (CFP) proposes to reduce unwanted by-catches and eliminate discards in European fisheries from: a specific legislation (in 2015), a reduction sequence and a plan for its application.

The reduction and elimination of discards requires changes in fisheries management, the adoption of measures on several fronts and the configuration of multidisciplinary initiatives. The analysis of the current situation of the discards of the most important Spanish fleets of trawl, gill and longline fisheries is the first fundamental step for the identification of the importance of the problem and the selection of the most problematic fisheries in relation to the production of discards.

In Europe, this understanding has specific policy relevance owing to recent reform of the EU Common Fisheries Policy. In Article 15 of the Common Fisheries Policy (CFP) Basic Regulation, which came into force on January 1st 2014, a phased discard ban or landing obligation for regulated species was introduced. Article 15 of the new CFP establishes the "landing obligation", which prohibits the discarding of species subject to catch limits (TAC and quotas) and those subject to minimum landing sizes (MLS) in the Mediterranean by January 2019. The policy includes several exemptions and flexibility tools. One exemption from the landing obligation is described for “species for which scientific evidence demonstrates high survival rates, taking into account the characteristics of the gear, of the fishing practices and of the ecosystem”.

With the new CFP, the multiannual plans will include the objective of the maximum sustainable yield and a deadline to achieve it, measures to implement the landing obligation and, among other things, guarantees of the application of corrective measures if necessary and revision clauses. They can also include technical measures.

The Scientific, Technical and Economic Committee for Fisheries (STECF / STECF) developed the guidelines to assist Member States in the formulation of joint recommendations to be included as a basis for regional pluriannual discard plans (STECF-13-23, STECF-14-01, STECF-14-06). These lines include:

a) Definition of fishing, management units and deadlines for implementation of landing obligation;

b) Exemptions based on the survival of discards;

c) "Minimis" exemptions (established to make the landing obligation more flexible in Article 15 of the new CFP);

d) Provisions on the documentation of the catches;

e) Establishment of minimum conservation reference sizes (MCRS: minimum conservation reference sizes);

f) Identification of potential indicators for future impact evaluations.

The new reduction/elimination measures for discarding associated with the new CFP for the trawling fleet operating in Divisions 8c and 9a, will imply important changes that will affect its activity. In this context, it is necessary to try to determine those species with high survival, with special attention to those that may be more limiting, called " choke species" due mainly to their low quota.

There is a perception by the fishermen of some species that could have a high survival rate in these fisheries, which could be returned alive to the sea avoiding the obligation to take them to port and thereby endanger fishing quotas with a premature closure of the fishery. The exemptions and flexibilities referred to in Article 15 of the CFP must be justified and supported by ad hoc scientific studies.

In this report we present results of research studies on discard survival rates of rays caught in commercial fisheries in north Spanish waters. This report includes two studies which are presented together:

1. Estimates of ray discard survival at bottom trawling fishing from captive observation experiments

2. Estimates of ray discard survival at trammel fishing from captive observation experiments

2. OBJETIVES

The objective of the studies was to evaluate and estimate the survival of the rays usually discarded in the bottom trawl and trammel fisheries to obtain scientific information and inform with scientific arguments about the request of the "exemption for a high survival" in SWW waters.

3. MATERIALS AND METHODOS

3.1. FISHERIES

The Spanish bottom trawl operating in the Northern and Western coastal waters (ICES Divisions VIIIc and IXa) is prosecuted by vessels with 28 m of average length. Trawlers operate on the continental shelf and upper slope from the southern Bay of Biscay to the northwest Spanish Iberian waters. The minimum depth for activity of this fleet is fixed to 100 meters.

The metier "Otter bottom trawl targeting demersal species (OTB_DEF_>=55)" in north Spanish Iberian waters targets demersal species, standing out hake (Merluccius merluccius), megrims (Lepidorhombus boscii and L. whiffiagonis) and anglerfish (Lophius piscatorius and L. budegassa). Vessels are from about 12 fishing ports: Galicia (A Coruña, Burela, Celeiro, Corme, Marin, Muros, Muxia, Ribeira, Vigo), Asturias (Avilés, Gijón) and Cantabria. The fishing gear characterized by a vertical opening of 1.2-1.5 m and a wingspread of 22-25 m, is allowed to use a codend mesh size of 70 mm. This is a mixed demersal fishery that catch skates (Rajidae) of several species.

The Spanish trammel net fishing is prosecuted by vessels with less than 15 m length. Vessels operate near the coast, mainly on the continental shelf. The target species are a large variety of demersal fish, including several species of rays and skates.

3.2. FISHING VESSELS IN SURVIVAL RESARCH TRIALS

3.2.1. STUDY 1: BOTTOM TRAWL MIXED FISHERY (TRIAL DESCARSEL0318)

The vessel used in trial 1 was the bottom trawler "Ensenada de Bueu" (length 24m, 145 tons) using a standard otter bottom trawl gear with a codend mesh size of 55 mm diamond. Tow durations were the normal commercial time of approximately 3 hours long.

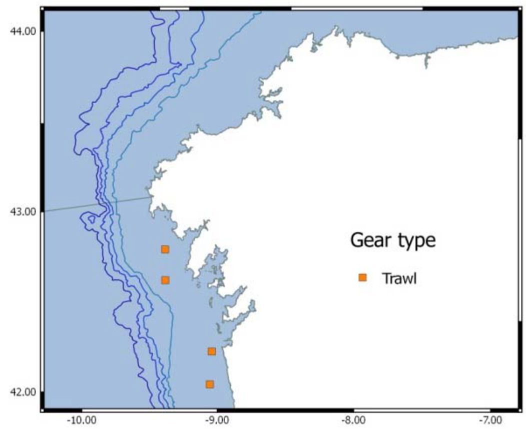


Figure 1. Spatial position of studied hauls during the trial 1.

3.2.2. STUDY 2: TRAMMEL ARTISANAL FISHERY (TRIAL DESCARSEL0418)

The vessel used in trial 2 was the artisanal vessel "Chapeliño" (length 14.95m, 21.59 tons, 200 HP) using two types of trammel net: a 1500 m length gear with mesh size of 200/800 mm and a 2000 m length gear with mesh size of 100/600 mm. Fishing durations were the normal commercial time of approximately 24 hours setting time.

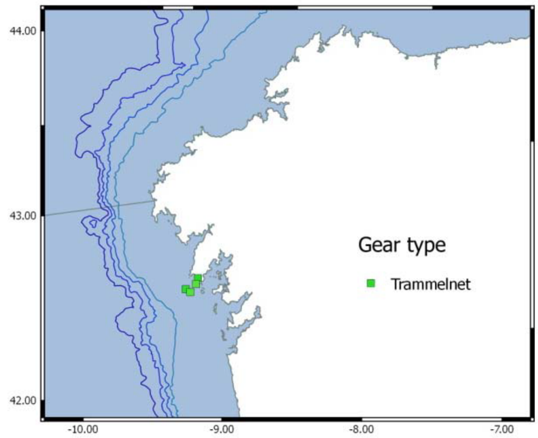


Figure 2. Spatial position of studied sets during the trial 2.

3.3. VITALITY ASSESSMENT ON BOARD

In each fishing operation, the individuals which were selected as discards and arrived with vitality signals to be alive at the fishing deck, were placed in tanks.

At trammel vessel, the tanks used are containers of 565 liters of food grade polyethylene, with double walls (sandwich type) and injected with polyurethane foam to guarantee a high isothermal capacity (see Figure 3). At trawling vessel 'Ensenada de Bueu', own metal tanks were used (see Figure 4).

These tanks have an open system 24 hours of seawater circulation without treatment. Using a portable oximeter, temperature and dissolved oxygen were measured at periodic intervals. To avoid problems of oxygen reduction, bottles of compressed oxygen (O2) with pressure regulator and a diffusing stone were used. The tanks are kept covered with a black shading cloth or isothermal covers. Videos were made with underwater cameras to monitor survival times and behavioral patterns of the species.

All the rays were assessed for vitality at vessel deck. They were assigned a vitality score following Catchpole et al, 2017. Table 1 presents criteria used to assess four health vitality status categories: Excellent, Good, Poor, Dead. Proportion of survival of rays in categories of health can be use to infer discard survival.

Table 1. Criteria for the assessed health status assigned to rays.

Health status	**Criteria**
Excellent	vigorous wing/body movement and rapid spiracle movement
Good	limp body/wing movement and spiracle movement
Poor	slight body movement with stimulation, slight movement of spiracles
Dead	no movement with stimulation

3.4. LONG-TERM SURVIVAL OBSERVATION IN TANKS ONSHORE

The alive fish were placed on board in the tanks to keep them until the end of the trip (18-24 hours trips). Every day, a special transport waited in the fishing port and the fish were transferred from the fishing vessel to the Aquaculture facilities of the IEO Vigo Oceanographic Center. The individuals were conditioned in tanks of 4000l, with a system of continuous open circulation and permanently controlled temperature and oxygen conditions (see Figure 5. The specimens were marked with microchips and size and weight were collected.

Observation of the vitality status of the specimens was carried out periodically every 12 hours during 30 days of captivity. The dead rays were removed from the tank and biologically sampled.

Survival data were fitted to a Kaplan-Meier model using the R function 'survfit'. Confidence intervals were computed on the log-log scale. This is a method that models survival as a function of time using non-parametric modelling. Longitudinal survival data are typically analysed using a class of methods referred to as “survival”, “failure” or “event” analysis(ICES, 2014). The advantage of the non- and semi-parametric approaches is that they make very few assumptions about the shape of the survivorship function. However, these methods are inappropriate for making predictions beyond the range of the data. The non-parametric Kaplan-Meier model (KM; also known as the product-limit estimator) calculates point-wise (in time) proportions of live organisms based on individual survival times, while accounting for censored observations. It is in effect the non-parametric maximum likelihood estimator of the survival function. It is the most commonly used non-parametric method (ICES, 2014).

Figura 3. Tank in trawling vessel Chapeliño'

Figura 4. Tanks in trawling vessel 'Ensenada de Bueu'

Figure 5. Aquaculture facilities of the IEO Vigo Oceanographic Center

3.5. TAGGING

The rays which survived all the long term study were marked with plastic "T-bar" marks suitable for the size of the fish. Two marks were inserted in the dorsal muscle of the pectoral fin, towards its back (Figures 6 and 7). Size and sex were registered together with the mark codes. A tagging reward scheme is established at fishing ports to encourage the recovery of tagged fish.

Figure 6. T-bar tag aplication in Raja clavata.

Figure 7. Tag insertion point in Raja clavata.

It is too early to have returns of tagged rays and the number is short at this state.

4. RESULTS

4.1. STUDY 1: BOTTOM TRAWL MIXED FISHERY

4.1.1. Sampling

Fishing hauls during study 1 results on the capture of one species: Thornback ray (*Raja clavata*). A total of 153 thornback rays were assessed for vitality and 78 placed to long-term study.

The rays were caught in four fishing trips from 22nd March 2018 and 28nd March. The fishing comprised of 5 hauls and each of which had a catch composed of mixed demersal species. The length distributions of the thornback rays are shown in Figure 8. A variety of commercial demersal species were caught and retained (european hake ,megrims, horse mackerel, mackerel, anglerfish, etc).

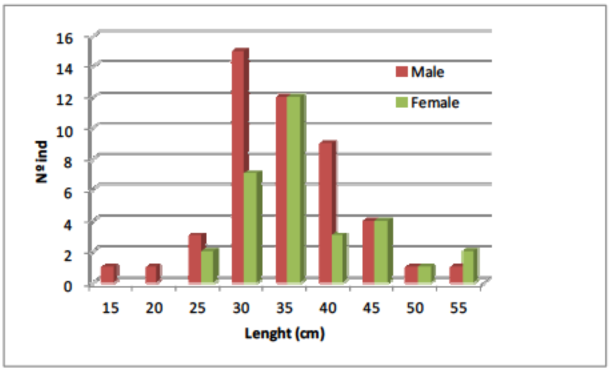


Figure 8. Length distribution size by sex of thornback rays at bottom trawl trials.

4.1.2. Vitality assessment

Results of vitality assessed to the thornback ray are presented Table 2. A percentage of 1.31% rays (n=2) were assessed as Excellent condition, 29.41% (n=45) were Good and 62.75% (n=96) were Poor, and 6.54% (n=10) were assessed as Dead.

Table 2. Survival of captive thornback ray by vitality status recorded on board.

Vitality	Number fish in tanks	Number fish captured	Porportion vitality in total catch
Excellent	1	2	1.31
Good	24	45	29.41
Poor	53	96	62.75
Dead	0	10	6.54

Results by fishing operation suggest differences between hauls in vitality proportions (Table 3). Haul on 27th March 2018 included a larger proportion of rays in poor condition (81%). During that trip it was registered a large catch of horse mackerel in the hauls with several tones in a single haul. Also during the trip 28th March 2018 a large catch of mackerel probably influenced the health status of rays and 79% were in 'Poor' condition.

Table 3. Survival of captive thornback ray during observation period by vitality status.

Fishing date	Fishing hour	Number of fish selected	Number of captured fish	Vitality	Number fish in tanks	Number fish captured	Porportion vitality in total catch	% survival captive fish (36h)	% survival captive fish (72h)	% survival captive fish (1 month)
22/03/2018	13:00	4	4	Excellent	0	0	0.00			
				Good	3	3	0.75	100	100	0
				Poor	1	1	0.25	100	0	0
				Dead	0	0	0.00			
22/03/2018	20:00	15	35	Excellent	1	2	0.06	100	100	100
				Good	12	22	0.63	100	75	58
				Poor	2	6	0.17	100	0	0
				Dead	0	5	0.14			
26/03/2018	13:00	4	10	Excellent	0	0	0.00			
				Good	2	3	0.30	100	50	0
				Poor	2	6	0.60	100	0	0
				Dead	0	1	0.10			
27/03/2018	09:00	30	57	Excellent	0	0	0.00			
				Good	4	9	0.16	100	75	0
				Poor	26	46	0.81	27	0	0
				Dead	0	2	0.04			
28/03/2018	10:00	25	47	Excellent	0	0	0.00			
				Good	3	8	0.17	100	100	100
				Poor	22	37	0.79	36	14	9
				Dead	0	2	0.04			

4.1.3. Survival estimation model

Figures 10 and 11 present the observed mortality of thornback in a medium and large term. The analysis shows differences between the observed survival of rays categorised as Poor compared with Excellent and Good rays.

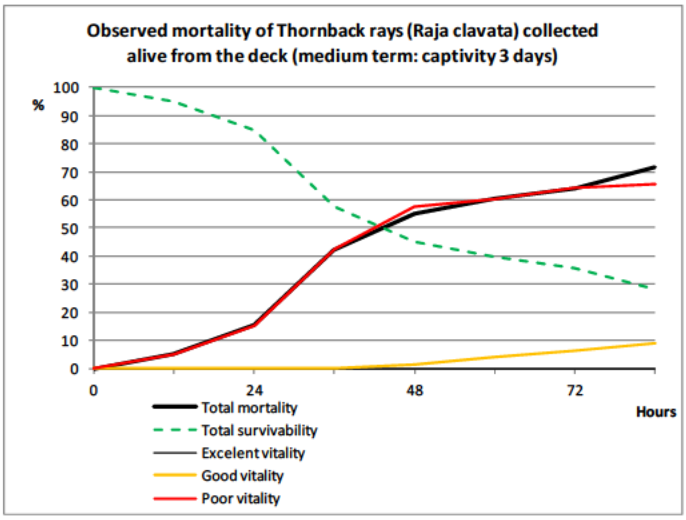


Figure 10. Observed mortality of thornback rays at a medium term (3 days of captivity). Total observed survivability and vitality of 3 vitality states are presented.

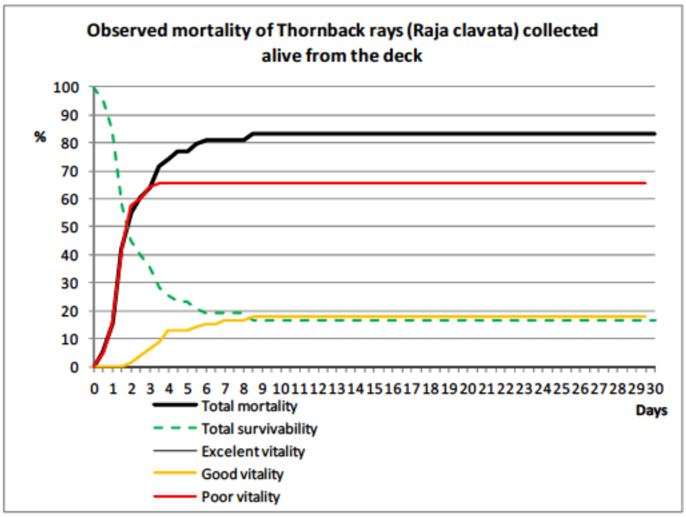


Figure 11. Observed mortality of thornback rays at a long term (3o days of captivity). Total observed survivability and vitality of 3 vitality states are presented.

Observed data were fitted to The Kaplan-Meier mortality model. The estimator generates the survivor function against time. K-M estimates with 95% confidence intervals were calculated for all rays (Table 5). Kaplan-Meier model plot is presented in Figure 12 and figure 13.

Table 5. Kaplan-Meier adjusted discard survival percentage: survival probability within the observation period with upper and lower 95% CIs (in brackets) from the K-M analysis.

time	n.risk	n.event	survival	std.err	lower 95% C	upper 95% CI
0.5	78	4	0.949	0.025	0.901	0.999
1	74	8	0.846	0.0409	0.77	0.93
1.5	66	21	0.577	0.0559	0.477	0.698
2	45	10	0.449	0.0563	0.351	0.574
2.5	35	4	0.397	0.0554	0.302	0.522
3	31	3	0.359	0.0543	0.267	0.483
3.5	28	6	0.282	0.051	0.198	0.402
4	22	2	0.256	0.0494	0.176	0.374
4.5	20	2	0.231	0.0477	0.154	0.346
5.5	18	2	0.205	0.0457	0.133	0.318
6	16	1	0.192	0.0446	0.122	0.303
8.5	15	2	0.167	0.0422	0.101	0.274

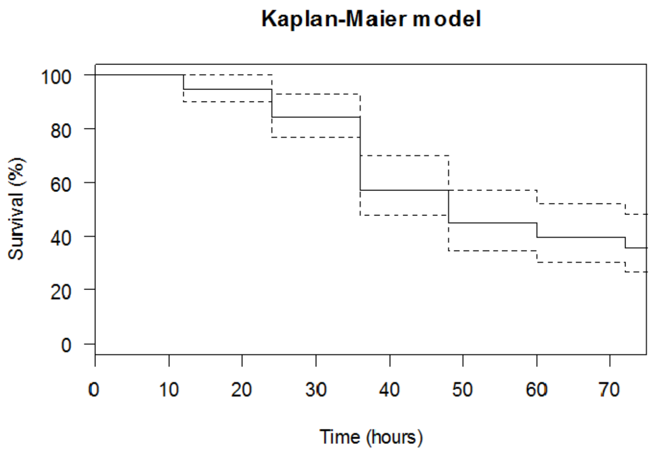


Figure 12. Kaplan-Meier estimates of survival at a medium term (3 days of captivity)(solid lines) and 95% pointwise confidence intervals as dashed lines.

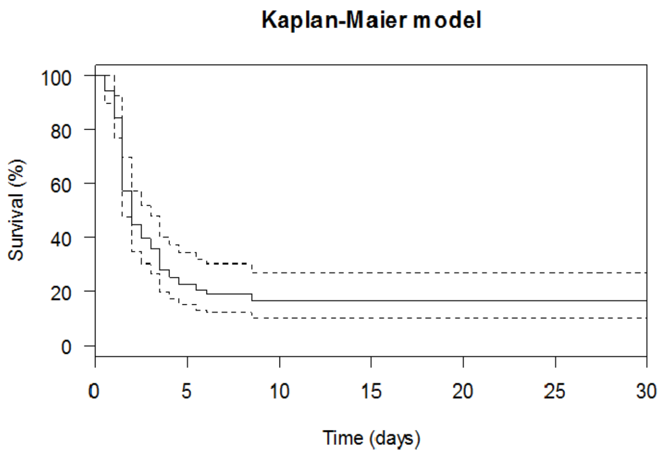


Figure 13. Kaplan-Meier estimates of survival at a long term (30 days of captivity)(solid lines) and 95% pointwise confidence intervals as dashed lines.

The K-M model estimations for health status and haul are shown in tables 6 and 7.

Table 6. Kaplan-Meier Survival modelling of captive thornback ray for health status "Good" and "Poor".

health=G						
time	n.risk	n.event	survival	std.err	lower 95% C	upper 95% CI
2.5	26	2	0.923	0.0523	0.826	1
3.5	24	3	0.808	0.0773	0.67	0.974
4	21	2	0.731	0.087	0.579	0.923
4.5	19	2	0.654	0.0933	0.494	0.865
5.5	17	2	0.577	0.0969	0.415	0.802
6	15	1	0.538	0.0978	0.377	0.769
8.5	14	2	0.462	0.0978	0.305	0.699
health=P						
time	n.risk	n.event	survival	std.err	lower 95% C	upper 95% CI
0.5	52	4	0.9231	0.037	0.85342	0.998
1	48	8	0.7692	0.0584	0.66283	0.893
1.5	40	21	0.3654	0.0668	0.25538	0.523
2	19	10	0.1731	0.0525	0.09555	0.314
2.5	9	2	0.1346	0.0473	0.06758	0.268
3	7	3	0.0769	0.037	0.03	0.197
3.5	4	3	0.0192	0.019	0.00276	0.134

Table 7. Kaplan-Meier Survival modelling of captive thornback ray for fishing trip.

tripID=19						
time	n.risk	n.event	survival	std.err	lower 95% C	upper 95% CI
12	25	4	0.84	0.0733	0.7079	0.997
24	21	8	0.52	0.0999	0.3568	0.758
36	13	2	0.44	0.0993	0.2827	0.685
48	11	2	0.36	0.096	0.2135	0.607
60	9	1	0.32	0.0933	0.1807	0.567
72	8	2	0.24	0.0854	0.1195	0.482
84	6	1	0.2	0.08	0.0913	0.438
tripID=20						
time	n.risk	n.event	survival	std.err	lower 95% C	upper 95% CI
36	30	19	0.3667	0.088	0.2291	0.587
48	11	6	0.1667	0.068	0.07488	0.371
60	5	2	0.1	0.0548	0.03418	0.293
84	3	1	0.0667	0.0455	0.01748	0.254
132	2	1	0.0333	0.0328	0.00485	0.229
204	1	1	0			
tripID=21						
time	n.risk	n.event	survival	std.err	lower 95% C	upper 95% CI
48	4	2	0.5	0.25	0.1877	1
60	2	1	0.25	0.217	0.0458	1
144	1	1	0			
tripID=22						
time	n.risk	n.event	survival	std.err	lower 95% C	upper 95% CI
72	19	1	0.947	0.0512	0.852	1
84	18	4	0.737	0.101	0.563	0.964
96	14	2	0.632	0.1107	0.448	0.89
108	12	2	0.526	0.1145	0.344	0.806
132	10	1	0.474	0.1145	0.295	0.761
204	9	1	0.421	0.1133	0.249	0.713

4.2. STUDY 2: TRAMMEL ARTISANAL FISHERY

4.2.1. Sampling

Fishing sets during study 2 results on the capture of four species: Thornback ray (*Raja clavata*), Spotted ray (*Raja montagui*), Small-eye skate (*Raja microocellata*) and Undulate ray (*Raja undulata*). Table 8 shows the number for each species. A total of 31 rays were assessed for vitality and 22 placed to long-term study.

Table 8. Rays captured by species

Species	Number fish in tanks	Number fish captured	Total
Raja clavata	6		6
Raja microcellata		1	1
Raja montagui	12	5	17
Raja undulata	4	3	7
Total Rajidae	22	9	31

The rays were caught in five fishing trips from 22nd April 2018 and 04st May 2018. The fishing comprised of 5 hauls and each of which had a catch composed of demersal species. The length distributions of the rays are shown in Figures 14-17. A variety of commercial demersal species were caught and retained (Spider crab, common sole, mackerel, gurnards).

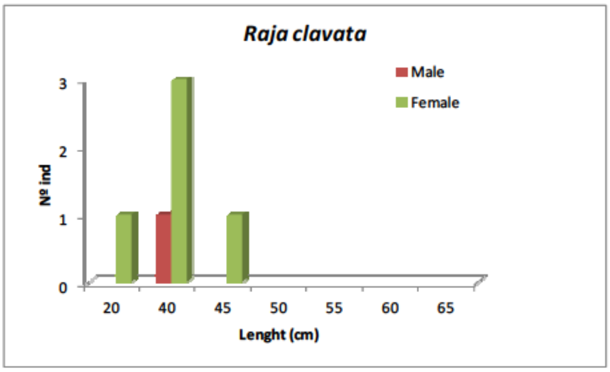


Figure 14. Length distribution size by sex of thornback rays at trammel net trials.

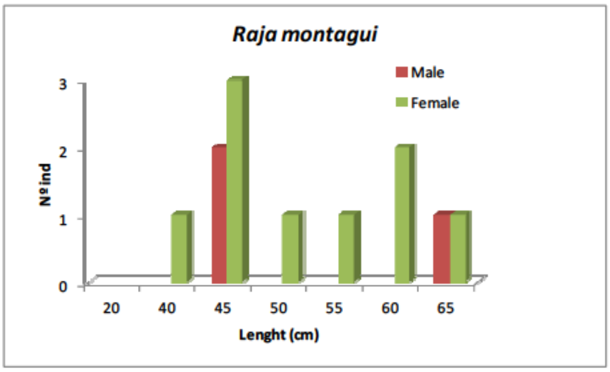


Figure 15. Length distribution size by sex of spotted rays at trammel net trials.

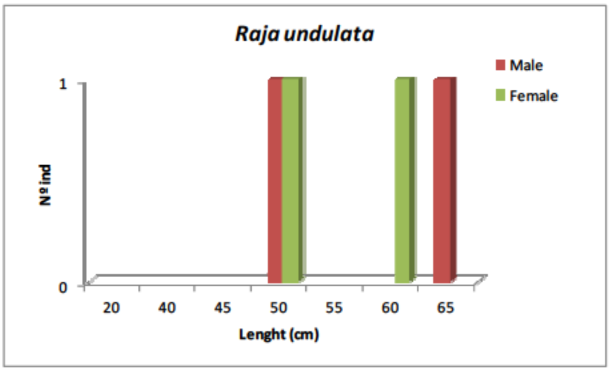


Figure 16. Length distribution size by sex of undulate rays at trammel net trials.

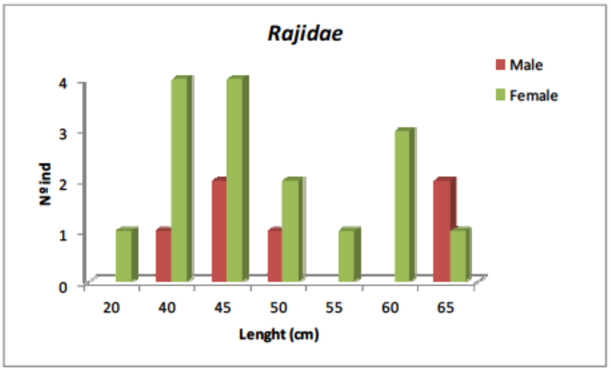


Figure 17. Length distribution size by sex of rays at trammel net trials.

4.2.2. Vitality assessment

Results of vitality assessed to the rays are presented table 9. A percentage of 67.74% rays (n=21) were assessed as Excellent condition, 32.26% (n=10) were Good and 12.90% (n=4) were Poor, and 0% (n=0) were assessed as Dead.

Table 9. Survival of captive rays by vitality status recorded on board.

Vitality	Number fish in tanks	Number fish captured	Porportion vitality in total catch
Excellent	14	21	67.74
Good	6	10	32.26
Poor	3	4	12.90
Dead	0	0	0.00

Results by fishing operation are similar between sets in vitality proportions (Table 10).

Table 10. Survival of captive rays during observation period by vitality status.

Fishing date	Fishing hour	Number of fish selected	Number of captured fish	Vitality	Number fish in tanks	Number fish captured	Porportion vitality in total catch	% survival captive fish (36h)	% survival captive fish (72h)	% survival captive fish (720h)
22/04/2018		11	14	Excellent	10	14	1.75	100	100	100
				Good	1	1	0.13	100	100	0
				Poor	0		0.00			
				Dead	0		0.00			
23/04/2018		5	8	Excellent	4	7	0.88	100	100	100
				Good	1	1	0.13	100	100	100
				Poor	0		0.00			
				Dead	0		0.00			
30/04/2018		1	3	Excellent	0		0.00			
				Good	1	3	1.00	100	100	100
				Poor	1	3	1.00	100	100	0
				Dead	0		0.00			
03/05/2018		2	3	Excellent	0		0.00			
				Good	1	3	1.00	100	100	0
				Poor	1		0.00	100	100	0
				Dead	0		0.00			
04/05/2018		3	3	Excellent	0		0.00			
				Good	2	2	0.67	100	50	50
				Poor	1	1	0.33	100	0	0
				Dead	0		0.00			

4.2.3. Survival estimation model

Figures 19 and 20 present the observed mortality of rays in a medium and large term. The analysis shows differences between the observed survival of rays categorized as 'Poor' compared with 'Excellent' and 'Good' rays.

Figure 19. Observed mortality of rays at a medium term (3 days of captivity). Total observed survivability and vitality of 3 vitality states are presented.

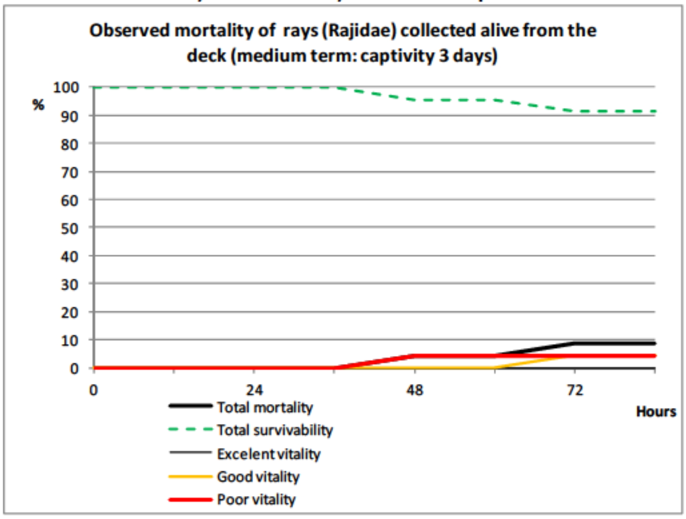
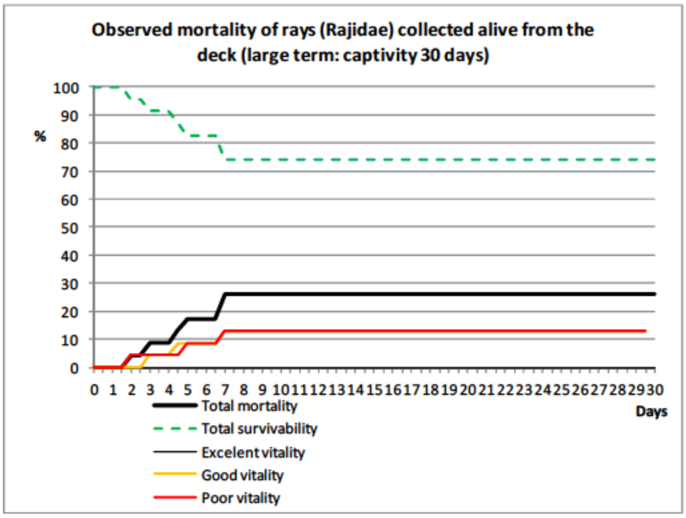


Figure 20. Observed mortality of rays at a long term (30 days of captivity). Total observed survivability and vitality of 3 vitality states are presented.



Observed data were fitted to The Kaplan-Meier mortality model. The estimator generates the survivor function against time. K-M estimates with 95% confidence intervals were calculated for all rays (Table 11). Kaplan-Meier model plot is presented in Figure 21 and figure 22.

Table 11. Kaplan-Meier adjusted discard survival percentage: survival probability within the observation period with upper and lower 95% CIs (in brackets) from the K-M analysis.

time	n.risk	n.event	survival	std.err	lower 95% C	upper 95% CI
48	22	1	0.955	0.0444	0.871	1
72	21	1	0.909	0.0613	0.797	1
108	20	1	0.864	0.0732	0.732	1
120	19	1	0.818	0.0822	0.672	0.996
168	18	2	0.727	0.095	0.563	0.939

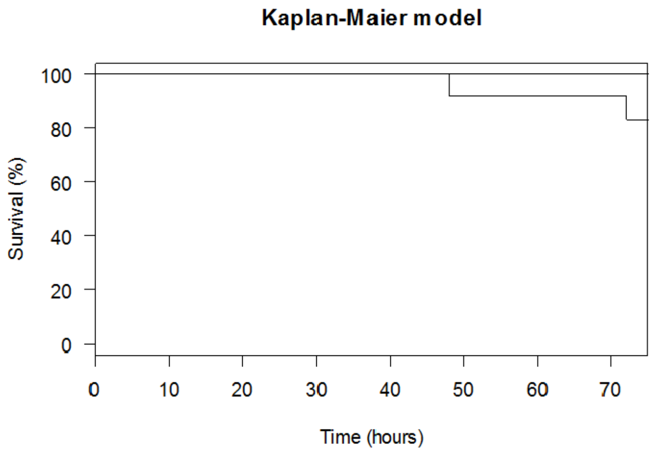


Figure 21. Kaplan-Meier estimates of survival at a medium term (3 days of captivity)(solid lines) and 95% pointwise confidence intervals as dashed lines.

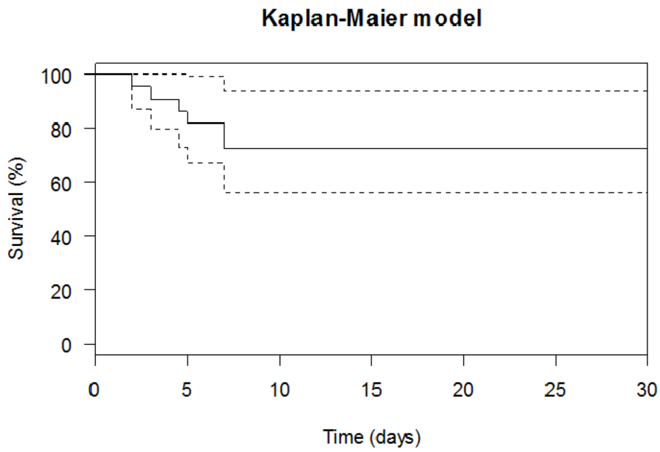


Figure 22. Kaplan-Meier estimates of survival at a long term (30 days of captivity)(solid lines) and 95% pointwise confidence intervals as dashed lines.

The K-M model estimations for health status and haul are shown in tables 12 and 13.

Table 12. Kaplan-Meier Survival modelling of captive rays for species.

species=Raja clavata						
time	n.risk	n.event	survival	std.err	lower 95% C	upper 95% CI
4.5	6	1	0.833	0.152	0.583	1
5	5	1	0.667	0.192	0.379	1
7	4	2	0.333	0.192	0.108	1
species=Raja montagui						
time	n.risk	n.event	survival	std.err	lower 95% C	upper 95% CI
2	12	1	0.917	0.0798	0.773	1
3	11	1	0.833	0.1076	0.647	1

Table 13. Kaplan-Meier Survival modelling of captive rays for fishing trip.

tripID=CHAP01						
time	n.risk	n.event	survival	std.err	lower 95% C	upper 95% CI
4.5	11	1	0.9091	0.0867	0.7541	
tripID=CHAP01						
time	n.risk	n.event	survival	std.err	lower 95% C	upper 95% CI
4.5	11	1	0.9091	0.0867	0.7541	
tripID=CHAP04						
time	n.risk	n.event	survival	std.err	lower 95% C	upper 95% CI
5	2	1	0.5	0.354	0.125	1
7	1	1	0			
tripID=CHAP05						
time	n.risk	n.event	survival	std.err	lower 95% C	upper 95% CI
2	3	1	0.667	0.272	0.2995	1
3	2	1	0.333	0.272	0.0673	1

5. CONCLUSIONS

The survival trials in this project followed the methods suggested by of ICES Workshop on Methods to Estimate Discard Survival (WKMEDS) and several survival studies(Ribeiro Santos, et al., 2016; Catchpole et al, 2017; Randall et al., 2017). The selected approach was to carry out vitality assessments at sea during normal fishing activity and a long-term captive observation experiment.

Fishing hauls during study 1 results on the capture of one species: Thornback ray (*Raja clavata*). A total of 153 thornback rays were assessed for vitality and 78 placed to long-term study. In study 1 at trawler, 62.75% of rays were recorded as in 'Poor' health condition. During two hauls, occurs a large catch of horse mackerel and mackerel that probably influenced the health status of rays because of the large volume of the codend.

The mortality rate at vessel deck, assessed when fish comes onboard, was 6.54%. Estimated survival at 36h was 58% (47.7-69.9).

Fishing sets during study 2 results on the capture of four species: Thornback ray (*Raja clavata*), Spotted ray (*Raja montagui*), Small-eye skate (*Raja microocellata*) and Undulate ray (*Raja undulata*). Table 8 shows the number for each species. A total of 31 rays were assessed for vitality and 22 placed to long-term study.

In study 2 at trammel net boat, 12.90% of rays were recorded as in 'Poor' health condition. The mortality rate at vessel deck, assessed when fish comes onboard, was zero%. Estimated survival at 48h was 95.5% (87.1-100)and it was 73% (56.3-93.9) at the end of the observed period (one month). *Raja clavata* scored the lower survivability (33.3%), *Raja montagui* intermediate (83,3%) and all specimens of *Raja undulata* survived the trial without mortality events.

Many factors influence survival and some of them are poorly understood and difficult to control across species, fisheries and areas: characteristics of the fishing haul (time, depth, speed, gear…), composition and volume of fish in the codend, time of capture in the fish, time of hauling onboard, handling by fishers, method of discarding, biology of species, etc.

On the other hand, several factors influence survival experiments, including the transport and captivity onshore of the fish. For the trawl experiment, captivity conditions onboard could influence in mortality rates, due rough weather at sea on 23-24th March 2018, as well as the density of fish vs water volume in the available tank. That could explain the long-term survivability in Raja clavata of 17% (10.1-27.4) at the end of the observed period (one month). Stress and conditions at captivity should be a factor to take into account in this study and to analyze in future works. Most of the thornback rays did not feed till 3 weeks at captivity which compromise the health status at captivity of the species. Spotted and undulate rays feed at captivity al the end of first week (3-7 days after fishing).

It is planned several workshops and dissemination of results to the fishing sector to advise them and encourage fishermen to good fishing discarding practices and involvement in research trials. The project DESCARSEL and stakeholders will produce a 'Guidelines of best practices: handling, maintenance and release of discarded rays'.

REFERENCES

Catchpole, T., Wright, S., Bendall, V., Hetherington, S., Randall, P., Ross, E., Santos, A. R., et al. 2017. Ray Discard Survival: Enhancing evidence of the discard survival of ray species. CEFAS Report: 1–70.

Enever, R., Catchpole, T.L., Ellis, J.R. and Grant, A. (2009) The survival of skates (Rajidae) caught by demersal trawlers fishing in UK waters. Fisheries Research 97, 72–76.

ICES (2014) Report of the Workshop on Methods for Estimating Discard Survival (WKMEDS), 17–21 February 2014. Copenhagen, Denmark.

Pérez, N., P. Pereda, A.Uriarte, V. Trujillo, I. Olaso y S. Lens, 1996. Descartes de la flota española en el área del ICES. Datos y Resúmenes. Vol 2. NIPO : 251-96-013-X.

Reglamento (UE) n.º 1380/2013 del Parlamento Europeo y del Consejo, de 11 de diciembre de 2013, sobre la política pesquera común, por el que se modifican los Reglamentos (CE) n.º 1954/2003 y (CE) n.º 1224/2009 del Consejo, y se derogan los Reglamentos (CE) n.º 2371/2002 y (CE) n.º 639/2004 del Consejo y la Decisión 2004/585/ CE del Consejo.

Randall, P, Ribeiro Santos, A., Firmin, C., O'Sullivan, H., White, E., Catchpole, T. (2017). Assessing the survival of discarded sole (Solea solea) in an English inshore trawl fishery, February 2017, Cefas report pp37.

Ribeiro Santos, A., Duggan, K., Catchpole, T. (2016). Estimating the discard survival rates of Common sole (Solea solea) in the English east coast inshore

Rochet M.-J., Arregi, L., Fonseca, T., Pereira, J., Pérez, N., Ruiz, J., and J. Valeiras, 2014. Demersal discard atlas for the South Western Waters. 121 pp.

Uhlmann, S. S., van Helmond, A. T. M., Stefánsdóttir, E. K., Sigurðardóttir, S., Haralabous, J., Maria Bellido, J., Carbonell, A., Catchpole, T., Damalas, D., Fauconnet, L., Feekings, J., Garcia, T., Madsen, N., Mallold, S., Margeirsson, S., Palialexis, A., Readdy, L., Valeiras, J., Vassilopoulou, V., and M-J. Rochet, 2013. Discarded fish in European waters: general patterns and contrasts. ICES Journal of Marine Science, doi:10.1093/icesjms/fst030.

Valeiras, J., Pérez, N., Araujo, H., Salinas, I. y J.M. Bellido, 2014. Atlas de los descartes de la flota de arrastre y enmalle en el caladero nacional Cantábrico-Noroeste. Instituto Español de Oceanografía. 122pp


Proyecto DESCARSEL
Investigadores y pescadores por la reducción de los descartes y la pesca sostenible
Instituto Español de Oceanografía