Cruise report:
Irish Anglerfish & Megrim Survey 2022

CE22004 and CE22007

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Cláir Chistí Eorpacha Struchtúrtha agus Infheistíochta na hÉireann 2014–2020

Cómhaoinithe ag Rialtas na hÉireann agus ag an Aontas Eorpach

An Roinn Talmhaíochta, Bia agus Mara
Department of Agriculture, Food and the Marine

European Union EMFF

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Suggested citation:

Kelly, E., Gerritsen, H., Aristegui Ezquibela, M., Moore, C., Moore, S. J., and Stokes, D. (2022). Cruise report: Irish Anglerfish & Megrim Survey 2022. FEAS Survey Series: IAMS 2022. Marine Institute

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Introduction

The 2022 Irish Anglerfish and Megrim Survey (IAMS) took place from 5th February to 1st March (area 7bcjk) and 12-22nd April 2022 (area 6a) on RV *Celtic Explorer*.

The main objective of the survey is to obtain biomass and abundance indices for anglerfish (*Lophius piscatorius* and *L. budegassa*) and megrim (*Lepidorhombus whiffiagonis* and *L. boscii*) in areas 6a (south of 58°N) and 7 (west of 8°W).

Secondary objectives are to collect data on the distribution, relative abundance and biology of other commercially exploited species.

For the fourth year, additional sampling took place in deep water (up to 1,500m) in order to monitor the recovery of exploited deep-water species following the decline of the deep-water fisheries in Irish waters.

The IAMS survey is coordinated with the Scottish Anglerfish and Megrim Survey (SIAMISS) and uses the same gear and fishing practices.

Methods

Stratification

The stratification is based on the following considerations:

- Depth: 0-200m; 200-500m; and 500-1,000m
- Clearly defined fishing grounds (from VMS-logbook data: Gerritsen and Lordan, 2011; Gerritsen *et al*., 2012) were identified as separate strata; an area with high fishing intensity surrounded by low fishing intensity signify that the bottom type and ecology on the fishing ground is different from that of the surrounding area. Examples include the Porcupine, Aran and Labadie *Nephrops* grounds, the Stanton Banks and Stags grounds.
- Catch rates of the target species (anglerfish and megrim) from VMS-logbook data as well as IBTS and previous Anglerfish and Megrim surveys were also taken into account in determining the boundaries of the strata.
- Rocky bottom types are excluded from the survey area which implies an assumption that the densities of the target species are zero in those areas.
- Regions 6a and 7bcjk are treated separately because they comprise different assessment and TAC areas.
- In addition to the main survey strata, additional deep water transects were added in deep water areas 4 and 5 (north of the Porcupine Bank and West of Donegal).
- IAMS 2021 completed five additional Marine Scotland stations that were located north of the main survey area in 6a.

The density of sampling stations in each stratum was either low, medium (twice the low density) or high (four times the low density). These station densities were assigned to each stratum so that the number of stations in each stratum would be roughly proportional to the expected standard deviation of the biomass estimate in the stratum.

Three small sampling strata with expected low abundance of the target species (Aran and Porcupine *Nephrops* grounds and the area of coarse sediment on the Porcupine Bank) were combined into a single stratum (‘VII_Shelf_L’) for estimation purposes, despite the differences in depth and bottom type. The naming of the strata reflects the region (VIa or VII), area (continental shelf or slope) and density of stations (Low, Medium, High). The final sampling strata and stations are shown in Figure 1.

Station selection

Sampling stations were selected at random in the following way:

1. Add a 30nm buffer around the survey area (to avoid edge effects)
2. Select 10,000 random points within the (buffered) survey area
3. Identify the pair of points that are closest to each other (nearest neighbour)
4. Remove the point of this pair that is closest to its second-nearest neighbour
5. Repeat steps 3. and 4. until only one point remains
6. Rank the stations in each stratum based on the order in which they were removed – giving stations removed last the highest priority – this ensures that regardless of how many stations are selected in a stratum, they will always be distributed approximately evenly (but randomly) in space

After selecting the random points, suitable tow tracks are identified that go through the random point. Where it was impossible to do so (owing to underwater cables, unsuitable bottom etc.) it was attempted to find a tow track that came within 1nm of the selected point.

As a result of Covid-19 restrictions on staff numbers, due to single cabin occupancy, fishing operations were reduced from 24 to 12 hours per day for Leg 1 and 2 and the number of stations achievable was reduced accordingly. The target number of stations for area 7bcjk was set at 65 stations. Covid-19 restrictions were removed prior to Leg 3 and 24 hour operations were reintroduced. The target number of stations for area 6a was normally 40 stations. However, unworkable conditions due to storms on Leg 2 resulted in 4 days from Leg 3 being used to sample stations on Porcupine Bank in area 7b. The remaining 6 days on Leg 3 were spent sampling stations to the North of Ireland and West of Scotland in area 6a. The target number of stations for 6a was therefore reduced from 40 to 24. This meant that stations with priority number 1-24 for area 6a and 1-65 for area 7bcjk respectively would be selected to be trawled. In practice it was not possible to sample all of the high priority stations (e.g. in cases where it was impossible to achieve a valid tow) and in this situation these stations can be replaced by the 'spare' stations with priority numbers >24 for area 6a and >65 for area 7bcjk respectively. In addition to the regular sampling strata there were also two 'deep water' transects included for the first time in 2019. These transects were each composed of 5 stations extending from 500-1,500m using the methodology of previous Marine Institute deep water surveys that were carried out between 2005 and 2009 (O'Hea *et al*., 2009).

Four to six weeks prior to the departure a Marine Notice was issued (www.dttas.ie) to advise seafarers and fishermen about the survey. This document included a brief description of the survey methods and objectives including a list and map of the location of the proposed stations.

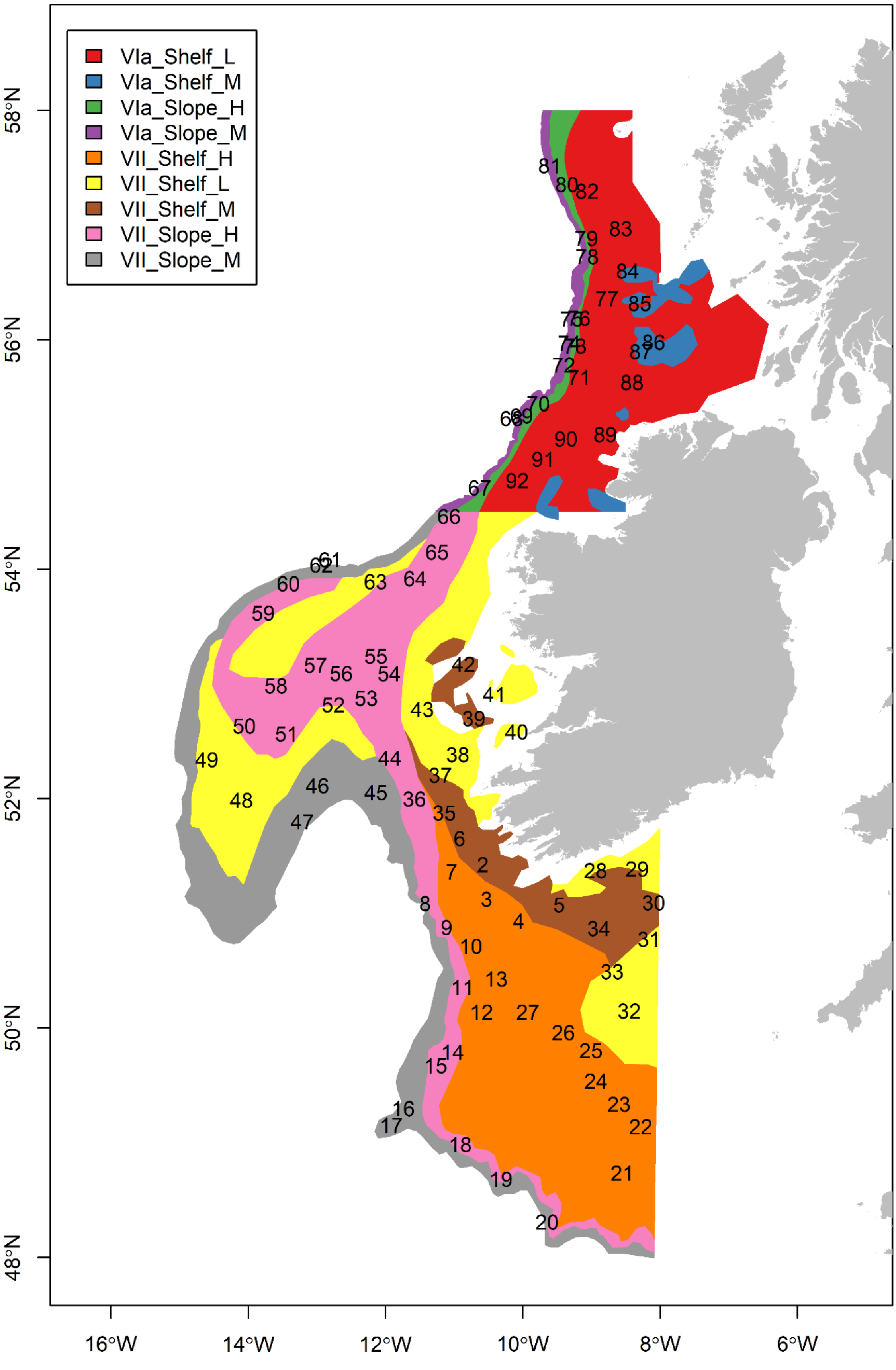

Figure 1*: Valid tow positions (the numbers refer to the haul number).*

Fishing operations

The trawl design is based on a standard commercial otter trawl used in the anglerfish fishery and is described in detail in Reid *et al*. (2007). The mesh size varies from 200mm in the wings gradually reducing to 100mm in the cod-end. The ground gear is fitted with 16’’ rock hopper disks and a 19mm tickler chain is mounted between the wings, rigged to run ahead of the ground gear. The trawl doors used were 5.45m^2 Thyboron Type 16 straight oval doors.

The gear was trawled at 3kn for one hour at each station. The warp to depth ratio was 3:1 for depths up to 200m, and 2:1 plus 200m in deeper water.

Door spread, wing spread, headline height and bottom contact were monitored using Scanmar and Marport trawl sensors (distance sensors in the doors and wing-ends, headline sensor and a trawl-eye sensor positioned on the top sheet directly over the footrope).

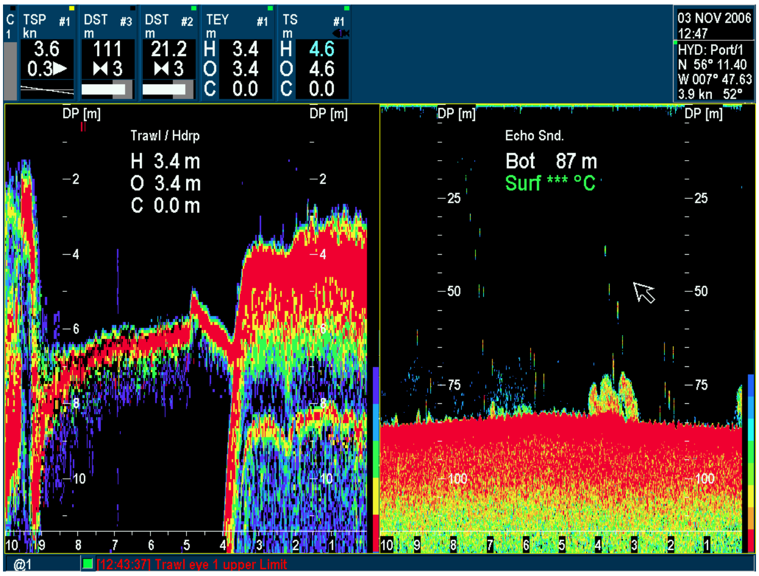

Figure 2: Screengrab of Scanmar display showing trawl geometry, water depth and fish marks

Wet lab protocol

All fish and invertebrate species were sorted and weighed (Table 1). Biological data were collected for the species listed in the
Table 2 below. Occurrence of the following vulnerable or sentinel invertebrate species was noted if present: corals, sea pen, fan mussel and ocean quahog.

Table 1: General sampling protocols

Priority	Task
1	Sort and sample anglerfish and megrim (For anglerfish also record the gutted weight).
2	Sort and weigh all fish and squid species, *Nephrops* and rubbish. Sort and enter benthos only for indicator species (corals, sea fans, sea pens, fan mussels, *Arctica islandica*), record weights & count as per Irish Ground Fish Survey. Record unsorted benthos as total weight using species code “BEN” and comment on main components in Notes. Take picture or preserve sample if unsure about ID and record as a comment.
3	Measure fish species listed in Table 2 below.
4	Take biological samples for the demersal listed in the Table 2 below.
Note: If it is not possible to complete all the work, drop tasks in reverse order as listed above. Never record sample weights for a few species; record all or just Anglerfish and Megrim. On invalid hauls it is still possible to collect biological data.	

Table 2: Detailed sampling protocols by species

	Species	Sort by sex	OTO box	Catch weight	Can you subsample	Bio target	Live weight	Sex	Mat	Age	Gutted weight
Aged demersal species	COD	U	100-149	yes	yes	1pcm	yes	yes	yes	yes	**yes**
	HAD	U	150-249	yes	yes	100%	yes	yes	yes	yes	no
	LIN	U	250-299	yes	yes	1pcm	yes	yes	yes	yes	no
	MEG	F/M	300-364 / 365-399	yes	**Preferably not**	1pcm	yes	yes	yes	yes	no
	MON*	U	400-499	yes	**never**	100%	yes	yes	yes	yes	**Yes**
	WAF*	U	500-599	yes	**never**	100%	yes	yes	yes	yes	**Yes**
	PLE	F/M	600-649 / 650-699	yes	yes	1pcm	yes	yes	yes	yes	no
	POK	U	700-749	yes	yes	1pcm	yes	yes	yes	yes	no
	POL	U	750-799	yes	yes	1pcm	yes	yes	yes	yes	no
	SOL	F/M	800-849 / 850-899	yes	yes	1pcm	yes	yes	yes	yes	no
	WHG	U	900-989	yes	yes	100%	yes	yes	yes	yes	no
Biological teleo	BLL	U	Spp#	yes	yes	1pcm	yes	yes	yes	no	no
	HKE	U	Spp#	yes	yes	1pcm	yes	yes	yes	no	no
	JOD	U	Spp#	yes	yes	1pcm	yes	yes	yes	no	no
	LBI	U	990-999	yes	yes	1pcm	yes	yes	yes	no	no
	LEM	F/M	Spp#	yes	yes	1pcm	yes	yes	yes	no	no
	TUR	U	Spp#	yes	yes	1pcm	yes	yes	yes	no	no
	WIT	U	Spp#	yes	yes	1pcm	yes	yes	yes	no	no
Bio elasmo	BLR	F/M	Spp#	yes	yes	1pcm	yes	yes	yes**	no	no
	CUR	F/M	Spp#	yes	yes	1pcm	yes	yes	yes**	no	no
	DGS	F/M	Spp#	yes	yes	1pcm	yes	yes	yes**	no	no
	DFL	F/M	Spp#	yes	yes	1pcm	yes	yes	yes**	no	no
	DII	F/M	Spp#	yes	yes	1pcm	yes	yes	yes**	no	no
	SDR	F/M	Spp#	yes	yes	1pcm	yes	yes	yes**	no	no
	THR	F/M	Spp#	yes	yes	1pcm	yes	yes	yes**	no	no
Others	NEP	U	-	yes	nemesys	nemesys	nemesys	nemesys		no	no
	Most other demersal fish species***			yes	Yes	Measured-only, no need to sort by sex					
	All pelagic fish species, squid; common demersals ***			yes	No length or biological samples						
	Invertebrates: Corals, sea fans, sea pens, fan mussels, Arctica islandica			Count & weight. If unsure about ID, take pic or freeze with haul label. For coral and *A. islandica* include comment on whether dead or alive							
	Other invertebrates			Total weight in comment field							
	Rubbish			As IGFS							
	CTD			As IGFS							

Key

Sex F/M: record catch weight by sex (flatfish and elasmobranchs); U: do not sort by sex.

Spp# use number allocated by Spp/Sex when prompted for otolith box. We use otolith process to ensure we get the maturity QC plots

subsample these species can be subsampled for length and biological data, if necessary

1pcm biological sampling target of one fish per cm size class (otolith target 1)

100% biological sampling target set per length group, i.e. targets vary by size class (otolith target 100%)

*
- Monk <20cm that are not clearly black should be id'd using dorsal fin ray counts: WAF 9-10; MON 11-12
- Cut illicia to around 1cm so they fit flat in the otolith box and clean them so they don't stick to the tissue
- When taking gutted weight, also remove the liver
- COLLECT OTOLITHIS FOR MON AND WAF in area 6!

** Only determine the maturity of female elasmobranchs if they are already dead, otherwise record as stage 9.

*** Do measure:
- All deep water species
- Large gadoids like ling, blue ling tusk
- All elasmobranchs except LSD
- Any demersal species that is not very common

Don't measure:
- Any pelagics (including boarfish, blue-mouth, argentines)
- Squid, octopus etc
- LSD (no need to record weight by sex either)
- Any flatfish not listed in the biological sampling table above
- Common demersal species of no or limited commercial value like gurnards, pout, poor cod, dragonets

Data collection and storage

Station positions, heading and bottom depth were recorded at the moment the gear settled on the bottom and when the gear lifts off on haul-back. Tide and wind direction and speed, barometric pressure, pitch and roll were recorded at the mid-point in the tow. The median values of the door spread, wing spread and headline height were recorded at the end of the tow. The CEFAS software FSS (Fishing Survey System) was used to enter station data and import catch data. These data are stored in a SQL database (FSS_SURVEY) on a local server.

The gear sensor data as well as bottom depth and GPS position were also recorded in a SQL database (FSS_NMEA) at intervals of approximately one per second.

Catch weights, length frequency distributions and biological data were captured using the EFDAQ (Electronic Fisheries Data Acquisition) system and stored into a local database in wet laboratory before being imported into the central SQL database (FSS_SURVEY).

Estimation

Catchability corrections for the two anglerfish species were applied following the methods described by the ICES working group WKAGME (2009). The equations were re-written to express the estimates in terms of capture probabilities (see also Yuan, 2012).

Footrope selectivity at length l, ($\hat{e}_{1l}$) was estimated using a 3-parameter logistic model:

$$\hat{e}_{1l} = \frac{1}{1 + \exp(-\beta_0 - \beta_1(l - \beta_2))}$$

$\beta_0 = 0.82257$, $\beta_1 = 0.11386$ and $\beta_2 = 35.5$

A herding coefficient ($\hat{h} = 0.017$) was applied to estimate herding in the area between the doors and wings (sweeps). The herding selectivity ($\hat{e}_{2li}$) was estimated as follows:

$$\hat{e}_{2li} = \frac{v_{1i} + \hat{h}v_{2i}}{v_{1i} + v_{2i}}$$

v_{1i} is the area swept by the footrope on tow i.
v_{2i} is the area covered by the sweeps on tow i.

The capture probability for a fish at length l in tow i in stratum s, (p_{lis}) is then given as:

$$p_{lis} = \hat{e}_{1l}\, \hat{e}_{2li} \frac{(v_{1i} + v_{2i})\, I_s}{A_s}$$

I_s is the number of hauls in stratum s.
A_s is the surface area of stratum s.

For megrim, no catchability correction is applied, so the capture probability is simply:

$$p_{is} = \frac{v_i\, I_s}{A_s}$$

The estimated number of fish ($\hat{N}$) or biomass (B) in the survey area are then:

$$\hat{N} = \sum\nolimits_{i \in I} \frac{n_i}{p_{lis}} \qquad \hat{B} = \sum\nolimits_{i \in I} \frac{n_i w_i}{p_{lis}}$$

n_l is the catch numbers-at-length in tow i
w_l is the mean weight-at-length, obtained from the length-weight relationship for the whole survey.

Changes in gear, protocols or estimation

During the 2016 survey:

- The tickler chain was fitted with a weak link that broke regularly. It was replaced with a G13 connector (not-so-weak link) at the end of the first leg.

Before the 2017 survey:

- The tickler chain was shortened so it is ~3m ahead of the footrope (Previously it was ~1.5-2m ahead of the footrope).
- The doors were modified by fitting a new top-end in order to increase their surface area from 5.25m^2 to approx. 5.45m^2 resulting in an additional 6% spreading power (estimated by supplier). This resulted in 4-5m extra door spread.
- The head rope was replaced and the floats were tidied up (tied on tighter and more regularly spaced). This resulted in an additional 60cm headline height, on average.
- The netting at the tips of the wings was replaced with stronger netting to avoid damage when it is pulled onto the drum on top of the floats.
- This was the first year a CTD was mounted on one of the trawl doors.

During the 2017 survey:

- The cod end was replaced after the area 7 part of the survey was completed (legs 1 and 2) but before the 6a part of the survey took place.

Before the 2018 survey:

- 1.2m length of chain added to the headline bridles. This chain was part of the design of the gear but was omitted from the gear plans. Fitting the chains resulted in an increase in the headline height of round 75cm and an increase in door spread of around 5m compared to 2017. There were no indications that fitting the chains changed the bottom contact or the amount of digging-in of the ground gear.

Before the 2019 survey:

- Additional deep water transects (500-1,500m) were added to survey protocols (3 additional days have been added to legs 1 and 2 to facilitate this work).
- In the middle of the Porcupine Bank there is some very soft ground. This may cause the gear to dig in (you see the door sensors getting unstable), reduce the warp to lift the gear a bit more. If this doesn't work, increase the speed a bit, e.g. up to 3.4-3.5 knots. (Soft ground can be quite dangerous if trawl belly fills up with mud!).
- The duration of leg 3 (6a) has been reduced due to over-sampling relative to the Marine Scotland effort; the target has been reduced from 50 to 40 stations.
- In case of extreme work pressure, there is an option to only process target species (MON, WAF, MEG; no catch weights or samples for other species). These stations will be flagged with validity code 'T' (This did not occur during IAMS 2019).
- There has been some inconsistency in recording the end of the tow in the past. Some SiCs recorded the end of the tow as the time when the gear is being hauled back, others as the time the gear lifts off the ground. It will be necessary to analyse the sensor data and apply corrections to the historic data in terms of tow length. From 2019 onwards, the end of the tow is being recorded as the time at lift-off.

Before the 2020 survey:

- Operational working hours on Leg III were reduced from 24 to 12 hours due to comply with Covid-19 restrictions. Staffing levels and targets were reduced proportionally.

Before the 2021 survey:

- Additional Marine Scotland stations in 6a (North of 58°) were added to survey plan.
- EFDAQ (Electronic Fisheries Data Acquisition) system used in wet lab (replaced the CEFAS EDC system)

Before the 2022 survey

- Operation working hours on Leg III were increased from 12 to 24 hours due to the lifting of Covid-19 restrictions on shared accommodation on-board the Celtic Explorer. Staffing levels and station target numbers were increased proportionally.

Results

Cruise summary

Storm 'Dudley' arrived on Wednesday 16th February with a status yellow wind warning in place which made the last day of Leg I unworkable. Storm 'Eunice' and 'Franklin' followed in quick succession with a status orange wind warning in place making the first 7 days of Leg II also unworkable. This was an unprecedented period of bad weather which resulted in Leg II scientific staff standing down from vessel on 21st February and re-joining on 24th February (Table 3). A full day of survey work was completed on 25th February with three stations completed but 26th February was again unworkable due to gale force winds. Another three stations were completed on 27th February and two more stations on 28th February. It was not possible to return to Galway City as planned due to a malfunctioning dock gate so the vessel returned to Cork City.

Due to the loss of working days during Leg I and Leg II it was decided to allocate some days from Leg III to cover the survey area to the West of Ireland. From 13th to 17th April, 23 stations were completed on the Porcupine Bank including two deep water stations. Another 24 stations were completed in the area to the North of Ireland (ICES Division 6a) from 17th to 21st April. Sea conditions were much improved during Leg III (12-24th April) with no downtime due to weather. During IAMS 2022 a total of 91 valid tows were completed (out of a target of 97), including 3 additional deep water tows (Table 4). There were two invalid hauls, one at the beginning of Leg I and another at the end of Leg III; a wing sensor was lost but there was no substantial damage to gear. Summary statistics by stratum for four main target species are provided in Table 5 (Note: Deep water stations are outside IAMS depth range and not included in this table).

Downtime

Table 3: Details of downtime during survey (Weather, technical and/or gear damage)

Date	Hours downtime	Reason
16/02/2022	24	Weather
18/02/2022	24	Weather
19/02/2022	24	Weather
20/02/2022	24	Weather
21/02/2022	24	Weather
22/02/2022	24	Weather
23/02/2022	24	Weather
24/02/2022	24	Weather
26/02/2022	24	Weather
Total	216 hours (9 days)	

Summary statistics

Table 4: Target and achieved stations by stratum

Stratum	Target	Valid	Invalid
DeepArea4	4	1	0
DeepArea5	4	2	0
VIa_Shelf_L	14	9	1
VIa_Shelf_M	7	4	0
VIa_Slope_H	10	5	0
VIa_Slope_M	9	7	0
VII_Porc_L	3	2	0
VII_Shelf_H	12	13	0
VII_Shelf_L	5	10	1
VII_Shelf_M	3	8	0
VII_Slope_H	17	22	0
VII_Slope_L	2	1	0
VII_Slope_M	7	7	0
Total	97	91	2

Table 5: Summary statistics by stratum. Stratum area is given in Km^2, 'Num hauls' is the is the number of valid hauls in each stratum and 'Swept Area' is the total area swept between the doors in each stratum (in Km^2), catch numbers ('Catch Num') are given for *L. piscatorius* (Mon), *L. budegassa* (Waf), *L. whiffiagonis* (Meg) and *L. whiffiagonis* (Lbi).

Stratum	Stratum Area	Num Hauls	Swept Area	Catch Num Mon	Catch Num Waf	Catch Num Meg	Catch Num Lbi
VIa_Shelf_L	37,003	9	3.3	60	4	26	0
VIa_Shelf_M	4,746	4	1.6	9	36	47	0
VIa_Slope_H	3,114	5	2.1	46	6	83	11
VIa_Slope_M	3,044	7	3.4	83	0	66	0
VII_Porc_L	11,798	2	1.1	17	0	16	261
VII_Shelf_H	50,764	13	6.5	62	310	283	35
VII_Shelf_L	22,322	10	5.1	76	104	63	0
VII_Shelf_M	14,621	8	4.0	62	170	76	10
VII_Slope_H	35,768	22	12.0	152	201	864	227
VII_Slope_L	7,914	1	0.6	0	5	2	2
VII_Slope_M	29,406	7	4.2	61	0	24	8
Total	220,500	88	43.9	628	836	1,550	554

Abundance and Biomass estimates

Estimated numbers and biomass for the survey area are given in Table 6. Note that it is likely that the selectivity correction does not account for all the fish encountered by the gear; therefore, these estimates should not be treated as absolute.

Table 6: Estimated numbers (millions; NumMln) and biomass (kT; BiomKT) in the survey area, with CV (relative standard error) and 95% confidence intervals (low:CiLo and high:CiHi). Only fish >500g live weight (approximately 32cm) were included in the estimate.

	VIa MON	VII MON	VIa WAF	VII WAF
NumMln	1.881	9.339	1.140	27.069
NumCV	42.403	15.404	25.292	18.016
NumCIlo	0.318	6.520	0.575	17.511
NumCIlo	3.443	12.159	1.704	36.628
BiomKT	3.162	15.951	0.504	16.213
BiomCV	44.231	9.994	30.227	15.803
BiomCIlo	0.421	12.827	0.205	11.191
BiomCIlo	5.903	19.076	0.803	21.235

Gear and fishing details

Figure 3 gives details of fishing net geometry of valid tows: distance towed, depth / warp length, warp length / door spread and door spread / wing spread. These show expected distributions and ranges.

Catch

The length-weight relationship for *L. piscatorius* and *L. budegessa* over the course of the survey followed expected relationships (Figure 4).

Figure 5 and Figure 6 summarise the catch weights of *L. piscatorius* and *L. budegessa* at each station across the survey area, and the size distribution of each species for assessment areas 6a and 7bcjk. Figure 7 displays the density of each species by stratum and associated standard error. *L. piscatorius* showed highest densities (kg/km^2) in the 'VIa Slope M' stratum and lower densities in the 'VII Shelf H' and 'VII Shelf L' strata. *L. budegessa* showed highest densities on 'VIa Shelf M' and lower densities on 'VIa Shelf L' and 'VIa Slope M' and were absent on the 'VII Slope M' stratum.

Figure 8 shows that the relative influence each of the stations had on the final density estimate was generally equitable (i.e. no single tow had a disproportionally large influence on the biomass estimates).

The trends in catch weights per swept area (Kg/Km^2) for anglerfish (*L. piscatorius*, *L. budegassa*) and megrim (*L. whiffiagonis*) from IAMS 2016 to 2022 are shown in Figure 9. For the anglerfish, the footrope and sweep selectivity were estimated as outlined in the Methods section. For megrim, no selectivity figures are available; 100% footrope selectivity was assumed and 0% sweep selectivity. Both species of anglerfish recorded the highest catch rates in 2017 for both assessment areas (6a and 7bcjk). Catch rates for white anglerfish (*L. piscatorius*) in area 7bcjk peaked in 2017 and declined from 2018 to 2021 although they have stabilised in 2022. Catch rates of black anglerfish (*L. budegassa*) had also been declining in this area but the value in 2022 was the highest in the time series. In area 6a the overall catch rates of white anglerfish have been declining since 2017 although this trend is uneven. Catch rates of black anglerfish in area 6a have been declining at a low rate since 2017. Catch rates for megrim (*L. whiffiagonis*) in area 7bcjk had been declining since 2016, but the value in 2022 is the highest in the time series. In area 6a Megrim catch rates have been more or less flat. It is important to note that for all three species the variability between years is within the uncertainty bounds, so there is no strong evidence of a trend.

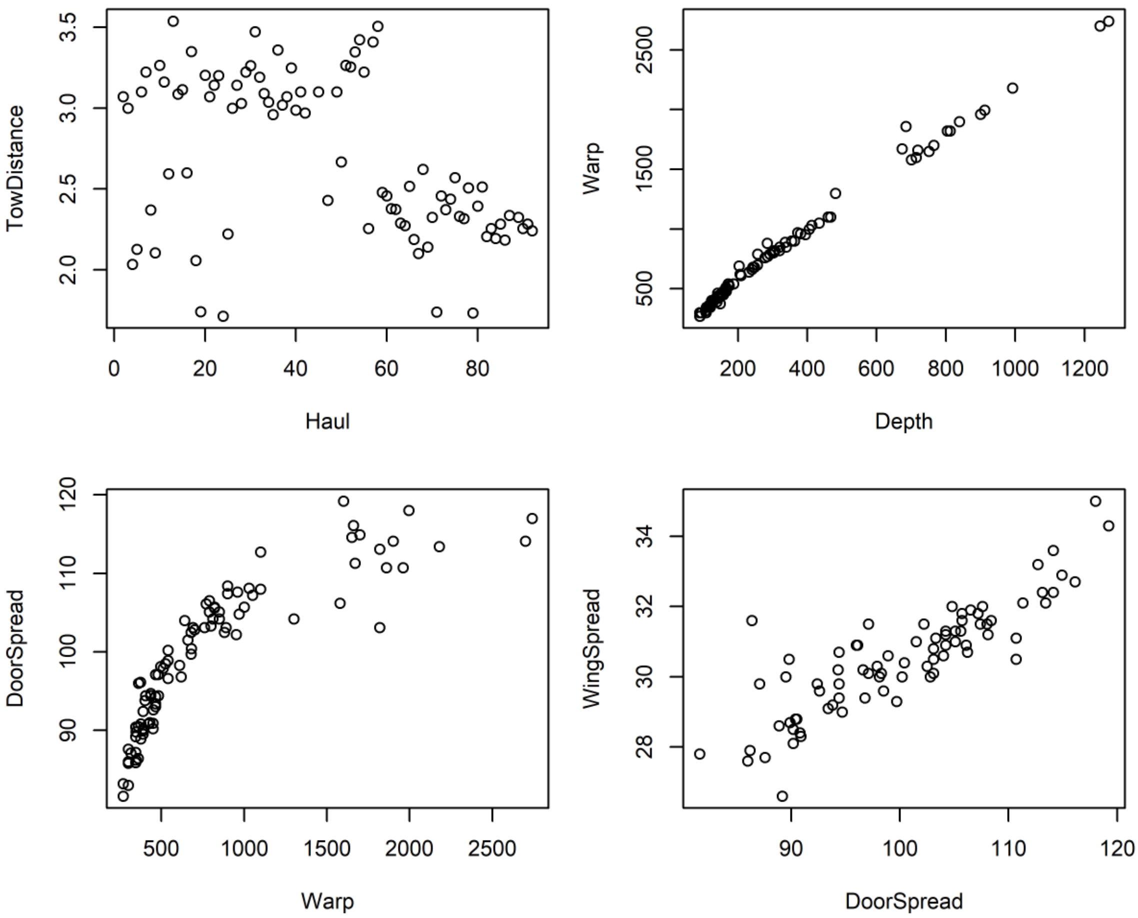

Figure 3: Gear parameters for the valid hauls. Haul is the haul number; Tow Distance in nautical miles; Warp, Depth, Door Spread and Wing Spread in meters

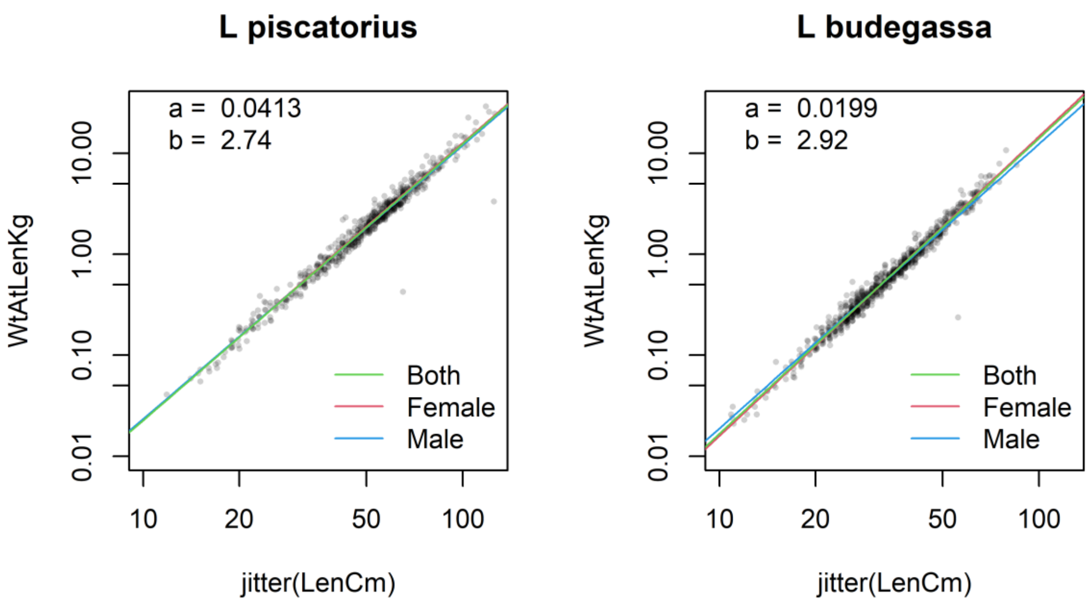

Figure 4: Length-weight parameters. Total length in cm and live weight in kg. Note the log scale.

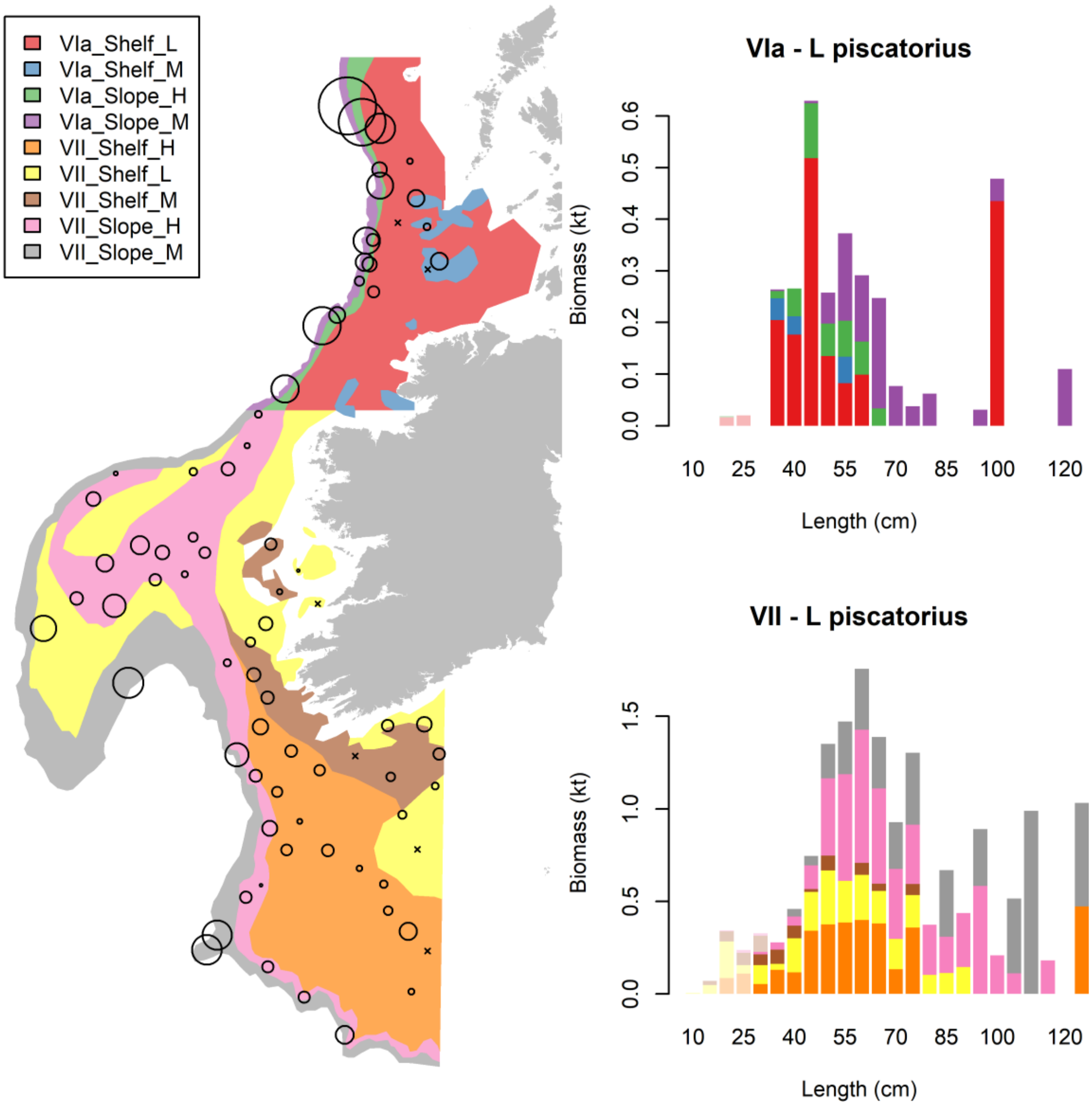

Figure 5: ***Bubble size is proportional to the biomass of*** **L. piscatorius** ***per swept area at each sampling station (left; >500g fish only) and biomass per size class and stratum (right; fish <500g in pale shades).***

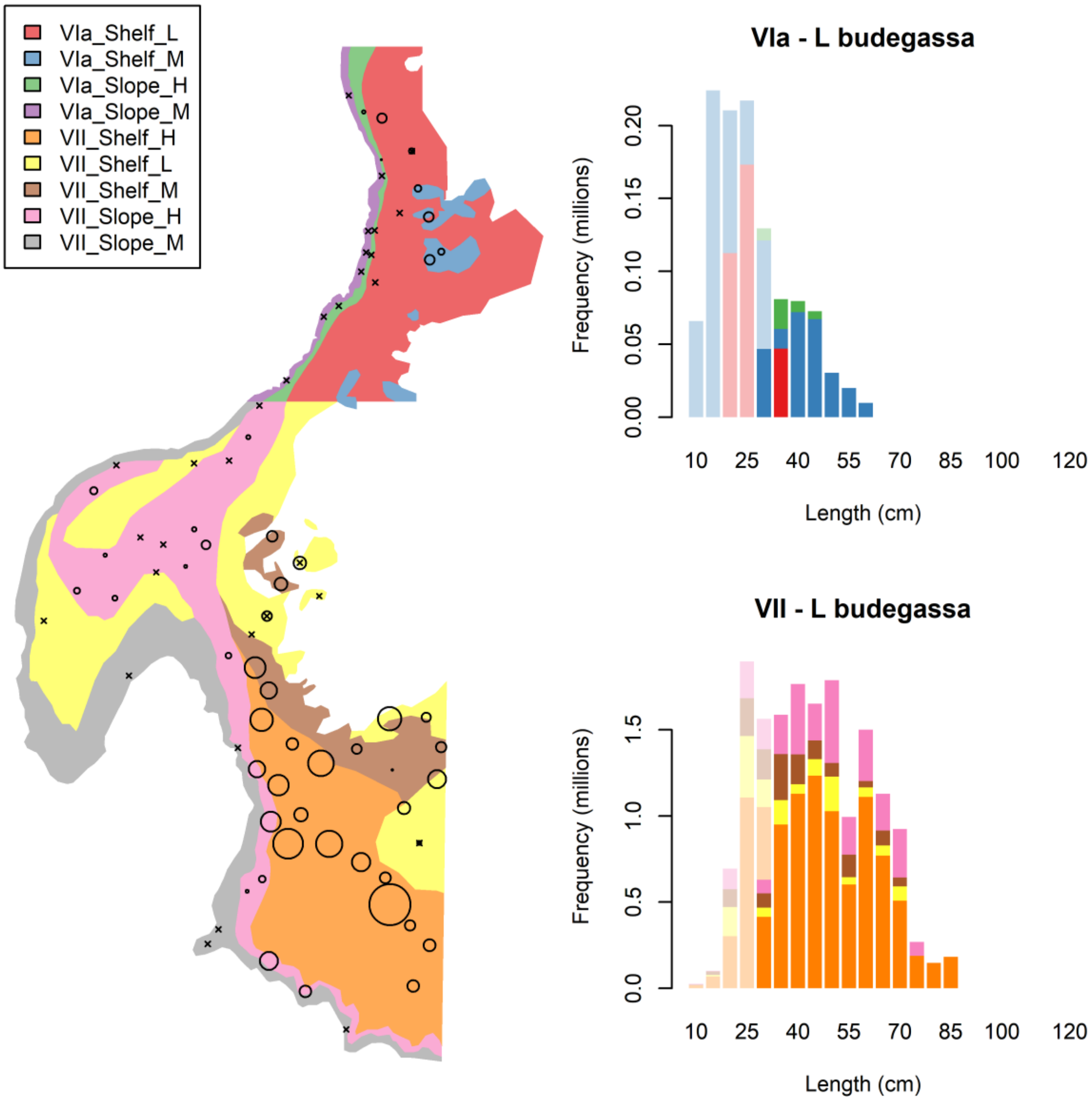

Figure 6: *Bubble size is proportional to the biomass of* L. budegassa *per swept area at each sampling station (left; >500g fish only) and biomass per size class and stratum (right; fish <500g in pale shades).*

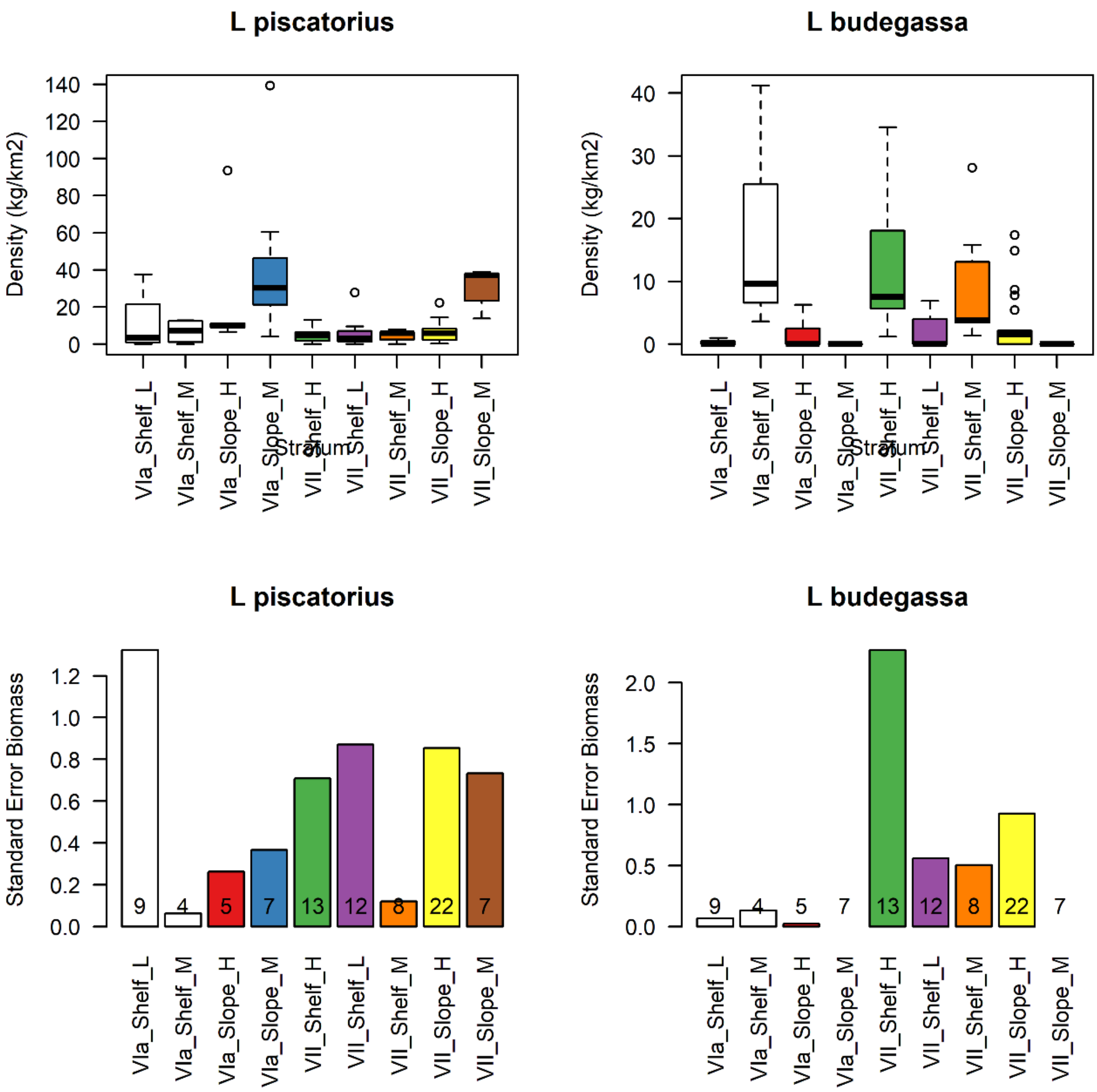

Figure 7: *Density (kg/km²) of* **L. piscatorius** *(Top Left) and* **L. budegassa** *(Top Right) and standard error of* **L. piscatorius** *and (Bottom Left)* **L. budegassa** *(Bottom Right) catches by stratum Note: Numbers in SE bar charts represent the total number of stations in each stratum*

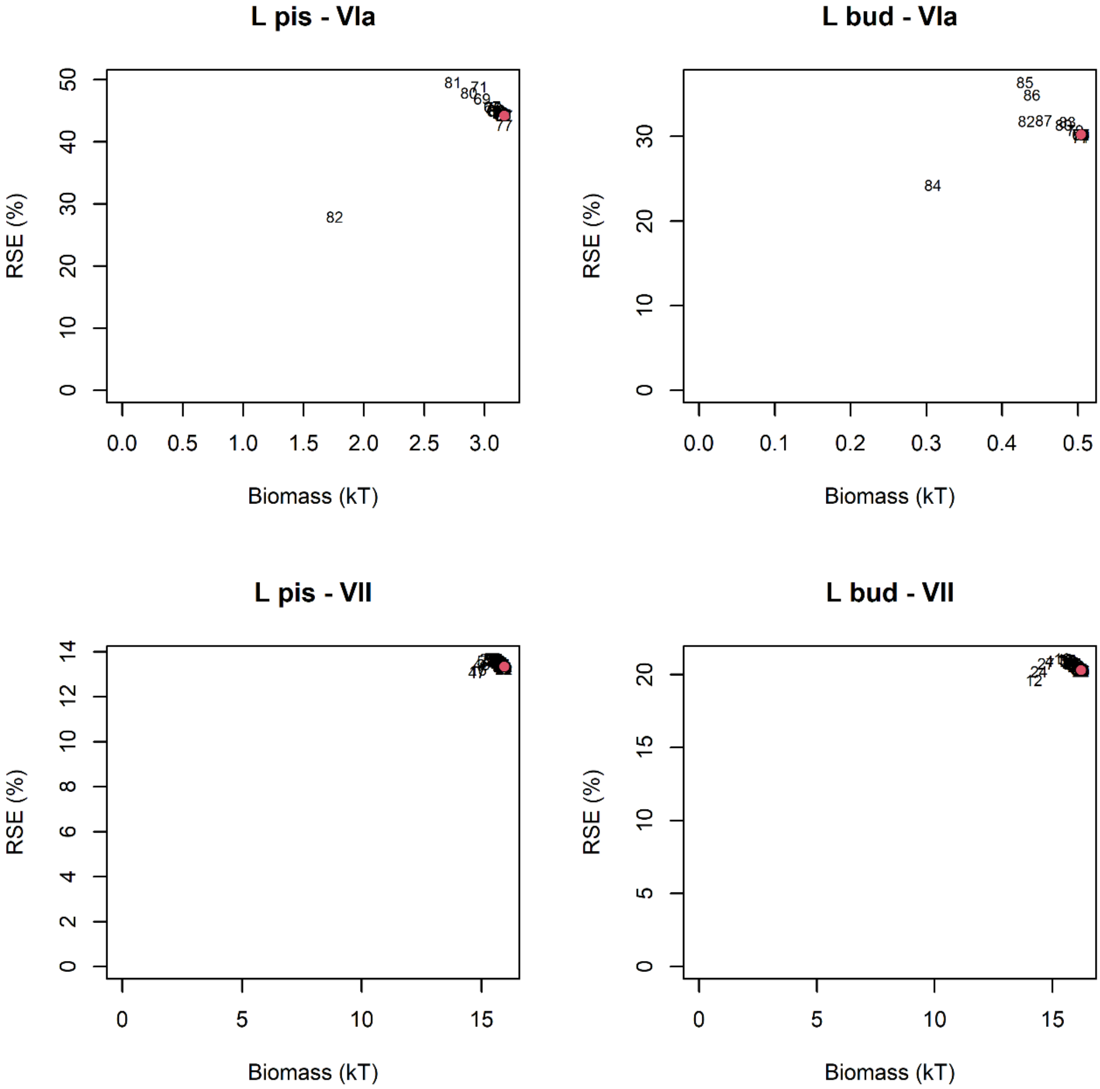

Figure 8: *Influence that each tow had on the final biomass estimate. Estimates were obtained by sequentially removing each of the tows from the analysis. The red dot indicates the final estimate (with all the valid tows included).*

Note: In area 6a, haul 82 was highly influential for L. piscatorius *(leaving this haul out would reduce the biomass estimate by more than a third). This haul was taken in stratum 'VIa_Shelf_L', which normally has a low abundance of anglerfish but covers a relatively large area. Even though only 19 while anglerfish were caught on haul 82; this was sufficient to increase the overall biomass estimate considerably. For* L. budegassa*, haul 84 was highly influential. This haul was taken in stratum 'VIa_Shelf_M', which was the only stratum with significant numbers of black anglerfish in area 6a. In Area 7 there were no hauls that stood out as being particularly influential.*

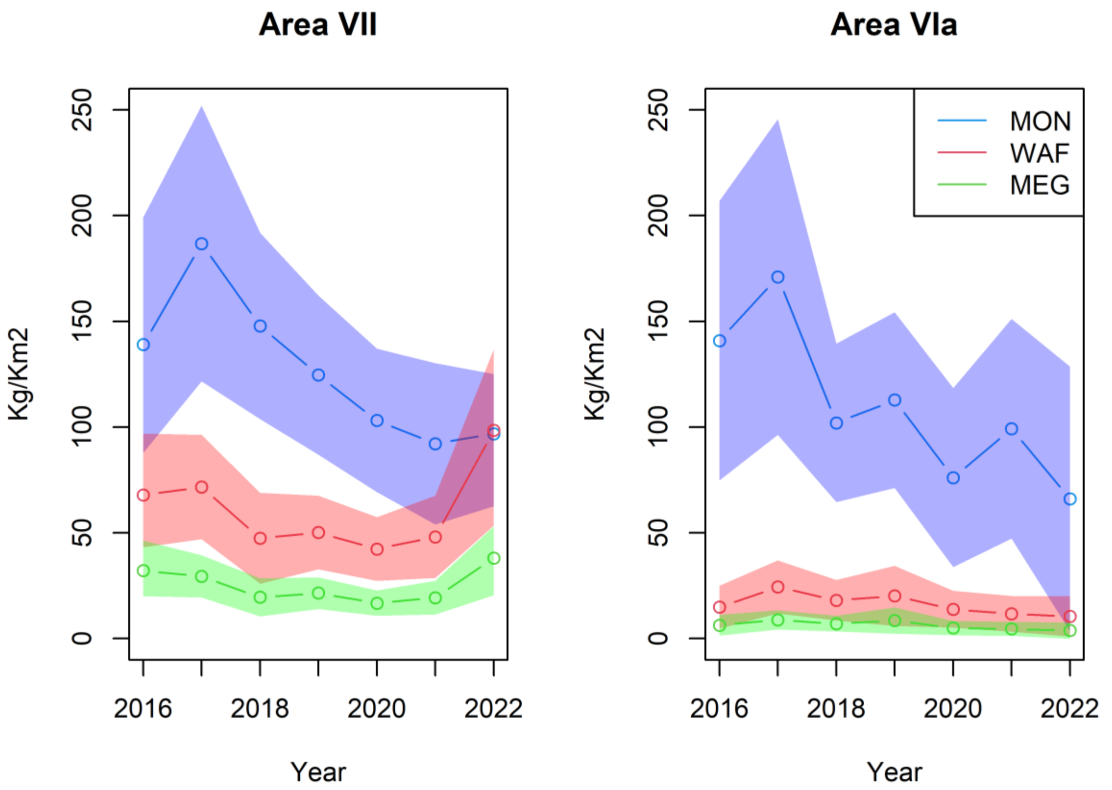

Figure 9: ***Trends in catch weights per swept area for white anglerfish (MON); black anglerfish (WAF) and megrim (MEG).***

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Appendix 1: List of IAMS 2022 survey staff

First Name	Surname	Organization	Survey Role	Participation Dates
Claire	Moore	Marine Institute	Chief Scientist	5/2/2022 - 17/2/2022
Ross	Fitzgerald	Marine Institute	Deckmaster	5/2/2022 - 17/2/2022
Mairead	Sullivan	Marine Institute	Deckmaster	5/2/2022 - 17/2/2022
Roxanne	Duncan	Marine Institute	Wetlab Scientist	5/2/2022 - 17/2/2022
Artur	Opanowski	Marine Institute	Wetlab Scientist	5/2/2022 - 17/2/2022
Sinéad	O'Brien	Marine Institute	Wetlab Scientist	5/2/2022 - 17/2/2022
Patrick	Keith	Smart Sea School	Wetlab Scientist	5/2/2022 - 17/2/2022
Nicoletta	Perrella	Survey Contractor	Wetlab Scientist	5/2/2022 - 17/2/2022
Bartley	Hernon	P&O Maritime	Gear Technologist	5/2/2022 - 17/2/2022
Tobi	Rapp	Marine Institute	Deckmaster	17/2/2022 - 1/3/2022
Sara-Jane	Moore	Marine Institute	Chief Scientist	17/2/2022 - 1/3/2022
Eoghan	Kelly	Marine Institute	Wetlab Scientist	17/2/2022 - 1/3/2022
Guillermo	Martin	Marine Institute	Wetlab Scientist	17/2/2022 - 1/3/2022
Turloch	Smith	Marine Institute	Wetlab Scientist	17/2/2022 - 1/3/2022
John	Enright	Marine Institute	Wetlab Scientist	17/2/2022 - 1/3/2022
Orla	Killeen	Smart Sea School	Wetlab Scientist	17/2/2022 - 1/3/2022
Domonique	Gillen	Smart Sea School	Wetlab Scientist	17/2/2022 - 1/3/2022
Frankie	McDaid	Survey Contractor	Wetlab Scientist	17/2/2022 - 1/3/2022
John	O'Regan	Survey Contractor	Gear Technologist	17/2/2022 - 1/3/2022
Dave	Stokes	Marine Institute	Chief Scientist	12/4/2022 - 22/4/2022
Gráinne	Ryan	Marine Institute	Deckmaster	12/4/2022 - 22/4/2022
Sean	O'Connor	Marine Institute	Deckmaster	12/4/2022 - 22/4/2022
Mikel	Aristegui Ezquibela	Marine Institute	Chief Scientist	12/4/2022 - 22/4/2022
Catherine	Waters	Marine Institute	Wetlab Scientist	12/4/2022 - 22/4/2022
Ross	O'Neill	Marine Institute	Wetlab Scientist	12/4/2022 - 22/4/2022
Dermot	Fee	Marine Institute	Wetlab Scientist	12/4/2022 - 22/4/2022
Helen	McCormick	Marine Institute	Wetlab Scientist	12/4/2022 - 22/4/2022
Turloch	Smith	Marine Institute	Wetlab Scientist	12/4/2022 - 22/4/2022
John	Enright	Marine Institute	Wetlab Scientist	12/4/2022 - 22/4/2022

Appendix 2: Additional Sampling

Request	Details	Requested by	Target
Nephrops	Nemesis catch sampling	Marine Institute	All
Litter	Litter log per tow	OSPAR	All
CTD on trawl door	Mini CTD	Oceanography Marine Institute	All
CTD transects	Main CTD	Oceanography Marine Institute	Opportunistic
IFI Sportfish Tagging	Tag & record elasmobranchs	Inland Fisheries Ireland	Opportunistic
NUIG Squid	*Illex coindetii* and *Loligo forbesii*	NUI Galway	70 specimens of each species
Hake and Anglerfish	Ethanol for DNA analysis	AZTI Technalia	90 from 6a and 7b-k
Sole genetics	*Solea solea* genetic samples	ILVO Belgium	60 specimens per ICES area
Sprat Genetics	Samples frozen at -80°C	Uppsala University	10 specimens from ICES Div. 6a

Appendix 3: Summary of station location, gear geometry and catch

Haul	Stratum	LonDeg W	LatDeg N	Depth mtr	Dist nm	Door mtr	Wing mtr	Mon Num	Waf Num	Mon Kg	Waf Kg
2	VII_Shelf_M	-10.5830	51.4255	154	3.1	93.0	NA	6	29	10.3	20.8
3	VII_Shelf_H	-10.5290	51.1245	159	3.0	94.4	29.4	7	8	11.5	3.9
4	VII_Shelf_H	-10.0615	50.9345	120	2.0	86.2	27.9	6	28	7.0	30.7
5	VII_Shelf_M	-9.4745	51.0740	123	2.1	88.9	28.6	2	8	0.6	3.5
6	VII_Shelf_M	-10.9225	51.6545	165	3.1	98.1	30	9	34	10.6	24.0
7	VII_Shelf_H	-11.0370	51.3620	188	3.2	100.2	30	12	29	23.4	17.3
8	VII_Slope_M	-11.4245	51.0875	482	2.4	104.2	31.3	10	0	19.9	0.0
9	VII_Slope_H	-11.1110	50.8770	243	2.1	102.5	30.3	6	25	18.1	25.1
10	VII_Shelf_H	-10.7575	50.7165	172	3.3	96.6	30.2	3	35	11.8	27.4
11	VII_Slope_H	-10.8815	50.3570	248	3.2	100.4	30.4	12	59	41.0	37.6
12	VII_Shelf_H	-10.6015	50.1410	153	2.6	93.4	29.1	4	53	9.1	57.8
13	VII_Shelf_H	-10.3905	50.4285	155	3.5	94.3	30.2	2	14	3.2	10.9
14	VII_Slope_H	-11.0260	49.7920	303	3.1	103.3	31.1	1	7	1.3	4.7
15	VII_Slope_H	-11.2725	49.6730	395	3.1	102.2	31.5	6	2	25.2	1.4
16	VII_Slope_M	-11.7445	49.2985	913	2.6	118.0	35	6	0	48.0	0.0
17	VII_Slope_M	-11.9175	49.1540	839	3.4	114.1	32.4	6	0	57.9	0.0
18	VII_Slope_H	-10.9145	48.9850	206	2.1	96.8	29.4	3	34	12.9	45.0
19	VII_Slope_H	-10.3200	48.6845	232	1.7	104.0	30.6	2	16	12.8	34.4
20	VII_Slope_M	-9.6495	48.3110	435	3.2	107.2	31.8	2	0	23.0	0.0
21	VII_Shelf_H	-8.5530	48.7375	165	3.1	97.9	30.3	2	11	3.5	15.3
22	VII_Shelf_H	-8.2855	49.1425	149	3.1	92.6	29.6	1	10	0.4	22.8
23	VII_Shelf_H	-8.6020	49.3365	144	3.2	94.4	30.7	3	5	42.1	21.7
24	VII_Shelf_H	-8.9340	49.5405	125	1.7	89.9	28.7	4	47	4.2	30.9
25	VII_Shelf_H	-9.0105	49.8035	131	2.2	94.4	29.8	1	6	3.9	8.6
26	VII_Shelf_H	-9.4105	49.9620	121	3.0	90.5	28.8	2	17	3.2	9.7
27	VII_Shelf_H	-9.9280	50.1405	124	3.1	93.8	29.2	15	47	15.9	58.6
28	VII_Shelf_L	-8.9415	51.3735	95	3.0	86.0	27.6	11	34	11.9	12.1
29	VII_Shelf_L	-8.3375	51.3865	90	3.2	81.6	27.8	12	8	16.3	11.2
30	VII_Shelf_M	-8.0960	51.0940	106	3.3	87.1	29.8	4	17	8.0	16.5
31	VII_Shelf_L	-8.1610	50.7760	117	3.5	96.0	30.9	3	31	4.5	18.9
32	VII_Shelf_L	-8.4520	50.1485	119	3.2	89.8	30.5	1	1	0.1	0.1
33	VII_Shelf_L	-8.7000	50.4925	122	3.1	96.1	30.9	2	14	6.8	15.4
34	VII_Shelf_M	-8.8930	50.8690	119	3.0	86.4	31.6	2	1	4.2	5.2
35	VII_Shelf_M	-11.1455	51.8770	173	3.0	98.9	30.6	11	55	10.7	41.8
36	VII_Slope_H	-11.5810	51.9985	286	3.4	106.1	30.9	6	7	8.7	9.2
37	VII_Shelf_L	-11.2010	52.2045	142	3.0	97.1	31.5	8	0	7.7	0.0
38	VII_Shelf_L	-10.9480	52.3860	124	3.1	92.4	29.8	15	5	13.0	0.6
39	VII_Shelf_M	-10.7155	52.6995	149	3.3	90.8	28.4	14	13	3.5	3.3
40	VII_Shelf_L	-10.0920	52.5835	90	3.0	87.6	27.7	17	0	2.3	0.0
41	VII_Shelf_L	-10.4120	52.9115	112	3.1	90.4	28.8	3	8	0.6	1.6
42	VII_Shelf_M	-10.8630	53.1720	128	3.0	90.2	28.5	14	13	8.2	5.6
43	VII_Shelf_L	-11.4655	52.7780	142	2.1	91.0	NA	4	3	6.4	0.7
44	VII_Slope_H	-11.9365	52.3530	336	3.2	103.1	NA	11	2	37.7	2.4
45	VII_Slope_M	-12.1420	52.0525	751	3.1	114.6	NA	14	0	70.0	0.0
46	VII_Slope_M	-12.9920	52.1130	714	3.2	119.2	34.3	18	0	92.2	0.0
47	VII_Slope_M	-13.2105	51.7990	900	2.4	110.7	30.5	5	0	46.7	0.0
48	VII_Slope_L	-14.1000	51.9860	355	3.2	108.4	31.6	0	5	0.0	0.4

49	VII_Porc_L	-14.6055	52.3395	406	3.1	105.7	31.6	16	0	71.1	0.0
50	VII_Slope_H	-14.0575	52.6340	257	2.7	106.5	31.9	3	4	23.3	5.3
51	VII_Slope_H	-13.4420	52.5640	339	3.3	105.1	31.3	16	5	91.2	9.7
52	VII_Slope_H	-12.7625	52.8185	461	3.3	112.7	33.2	7	0	25.7	0.0
53	VII_Slope_H	-12.2820	52.8765	321	3.3	104.2	31.2	3	3	8.7	3.3
54	VII_Slope_H	-11.9500	53.0895	209	3.4	98.3	30.1	11	17	22.4	23.8
55	VII_Slope_H	-12.1430	53.2425	278	3.2	103.1	30.8	5	4	17.7	7.7
56	VII_Slope_H	-12.6485	53.0915	381	2.3	107.6	32	8	0	25.9	0.0
57	VII_Slope_H	-13.0220	53.1625	307	3.4	105.7	31.8	11	0	71.5	0.0
58	VII_Slope_H	-13.5970	52.9855	203	3.5	103.1	30.5	20	4	59.5	10.7
59	VII_Slope_H	-13.7825	53.6190	292	2.5	105.1	31	9	8	27.3	7.4
60	VII_Slope_H	-13.4155	53.8740	413	2.5	108.1	31.2	1	0	2.4	0.0
61	DeepArea5	-12.8080	54.0845	1270	2.4	117.0	NA	0	0	0.0	0.0
62	DeepArea5	-12.9375	54.0360	992	2.4	113.4	32.1	1	0	5.9	0.0
63	VII_Porc_L	-12.1440	53.8925	372	2.3	104.8	32	1	0	4.4	0.0
64	VII_Slope_H	-11.5700	53.9190	320	2.3	105.6	31.3	7	0	22.9	0.0
65	VII_Slope_H	-11.2505	54.1495	304	2.5	104.2	30.9	2	4	4.6	6.5
66	VII_Slope_H	-11.0735	54.4620	468	2.2	108.0	31.5	2	0	6.5	0.0
67	VIa_Slope_M	-10.6300	54.7105	804	2.1	103.1	30.1	4	0	31.3	0.0
68	DeepArea4	-10.1655	55.3150	1245	2.6	114.1	33.6	0	0	0.0	0.0
69	VIa_Slope_M	-10.0200	55.3370	719	2.1	116.1	32.7	18	0	60.9	0.0
70	VIa_Slope_H	-9.7730	55.4430	363	2.3	107.4	31.5	3	0	7.6	0.0
71	VIa_Shelf_L	-9.1750	55.6745	111	1.7	89.2	26.6	4	0	3.5	0.0
72	VIa_Slope_M	-9.4065	55.7810	674	2.5	111.3	32.1	2	0	4.3	0.0
73	VIa_Slope_H	-9.2395	55.9465	256	2.4	102.8	30	2	0	6.1	0.0
74	VIa_Slope_M	-9.3250	55.9705	700	2.4	106.2	30.7	5	0	12.3	0.0
75	VIa_Slope_M	-9.2900	56.1815	812	2.6	113.1	32.4	9	0	38.0	0.0
76	VIa_Slope_H	-9.1840	56.1885	240	2.3	101.5	31	4	0	4.4	0.0
77	VIa_Shelf_L	-8.7750	56.3600	139	2.3	94.7	29	0	0	0.0	0.0
78	VIa_Slope_M	-9.0655	56.7265	685	2.5	110.7	31.1	7	0	36.5	0.0
79	VIa_Slope_H	-9.0770	56.8850	285	1.7	102.5	30.3	2	1	4.5	1.2
80	VIa_Slope_H	-9.3600	57.3545	247	2.4	99.7	29.3	35	5	55.6	3.7
81	VIa_Slope_M	-9.6075	57.5185	765	2.5	114.9	32.9	38	0	170.7	0.0
82	VIa_Shelf_L	-9.0655	57.2950	143	2.2	90.8	28.4	19	3	41.1	1.3
83	VIa_Shelf_L	-8.5755	56.9695	139	2.3	89.5	30	2	1	1.6	0.3
84	VIa_Shelf_M	-8.4735	56.5995	167	2.2	97.1	30.1	4	12	5.3	19.4
85	VIa_Shelf_M	-8.2985	56.3180	154	2.3	90.9	28.3	1	9	0.8	6.0
86	VIa_Shelf_M	-8.0945	55.9790	158	2.2	90.2	28.1	4	6	4.9	4.4
87	VIa_Shelf_M	-8.2825	55.8975	175	2.3	98.5	29.6	0	9	0.0	2.6
88	VIa_Shelf_L	-8.4110	55.6290	91	2.6	85.8	NA	2	0	0.8	0.0
89	VIa_Shelf_L	-8.8025	55.1760	91	2.3	83.2	NA	3	0	1.6	0.0
90	VIa_Shelf_L	-9.3745	55.1370	108	2.3	83.0	NA	4	0	5.1	0.0
91	VIa_Shelf_L	-9.7050	54.9585	109	2.3	85.9	NA	19	0	23.1	0.0

Notes:

Valid stations only.
LonDegW and LatDegW are the mid-point positions of each haul.
Depth mtr is the average depth of the haul.
Dist nm is the tow distance in nautical miles.
Door mtr and Wing mtr are the median door and wing spread.
Mon/Waf num/kg are the catch numbers and weights of *L. piscatorius* and *L. budegassa*.