Stock Annex: Sprat (*Sprattus sprattus*) in divisions 7.de (English Channel)

Stock specific documentation of standard assessment procedures used by ICES.

Stock: Sprat (*Sprattus sprattus*) in Divisions 7.de (English Channel)

Working Group: Herring Assessment Working Group for the Area South of 62ºN (HAWG)

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A. General

A.1. Stock definition

Divisions 7.d and 7.e comprise a management unit for sprat, with an annual TAC being set by the EC. However, it is not clear whether the sprat populations in this area constitute a unit stock and if this is an appropriate management unit. Until more information is available, advice will be given for this unit, mainly based on information from the Lyme Bay (ICES statistical rectangles 29 and 30 E6, 7) (Figure 1).

Most of the catch is taken in Lyme Bay in Subdivision 7.e, where ~90% of landed sprat are caught.

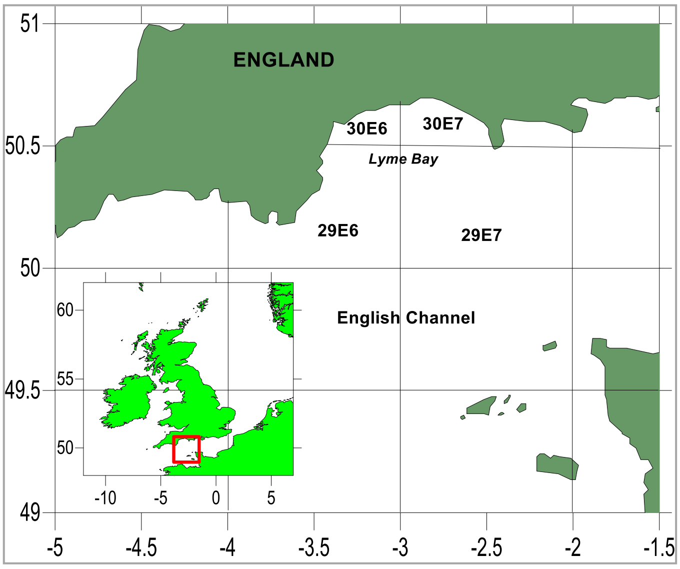

Figure 1. Sprat in 7.d, e, Lyme Bay. ICES statistical rectangles that constitute Lyme Bay are indicated.

A.2. Fishery

In Lyme Bay the primary gear used for sprat is midwater trawl. Within that gear type three vessels under 15 m actively target sprat and are responsible for the majority of landings (since 2014 they took on average 85% of the total landings). Sprat is also caught by driftnet, fixed nets, lines and pots. Most of the landings are sold for human consumption. The fishery starts in August and runs into the following year into February and sometimes March.

Sprat may also be caught in herring fisheries mixed shoals with herring. The level of discarding is unknown but believed to be negligible.

A.3. Ecosystem aspects

Fishermen find sprat by sonar search and sometimes the shoals have been too far offshore for sensible economic exploitation. Skippers then go back to other trawling activity. This offshore/near shore shift may be related to environmental changes i.e. temperature and/or salinity.

B. Data

B.1. Commercial catch

Sprat landings prior to 1985 in 7.de were extracted from STATLANT27 (Historical Nominal Catches 1950–2010), from 1985 onwards they are ICES estimates. Since 1985, sprat catch has been taken mainly by UK, England and Wales, with some substantial catches taken by Denmark in the late 1980s. Early landings from Denmark are being looked into as there may be some discrepancies between STATLANT27 and ICES data.

UK landings data are available by gear type from 1981 to date. For trawlers, associated effort was recorded both as number of days and hours fishing. In the case of driftnets effort corresponds to number of hauls times the total number of nets and for gillnet the length of the gear (m) times the number of days fishing. Technological improvements in the fishery such as high technology sonars (such as CH 32), were put in place in the early 1980s.

There is a TAC for sprat for 7.de, i.e. English Channel.

B.2. Biological

Catch sampling information became available to ICES in 2018 through a self-sampling programme and the official data collection framework: the target of the catches are mostly adults, with bulk of the catches represented by ages 1 to 3, average length around ~12 cm (Figure 2).

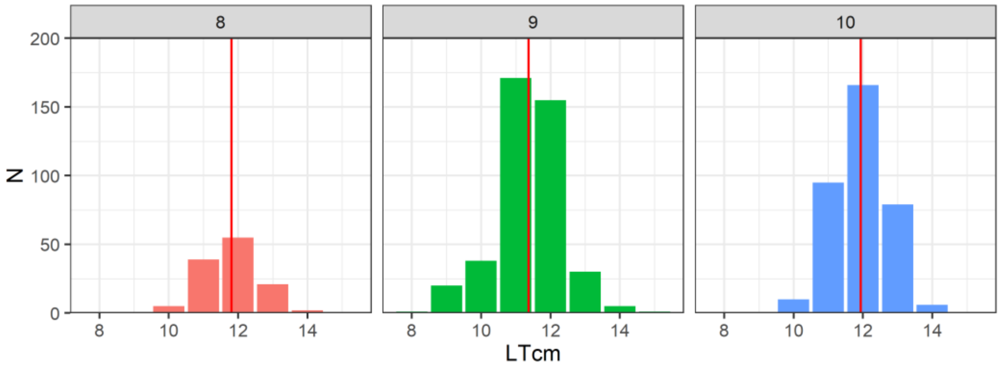

Figure 2. Sprat 7.d-e. Monthly (August to October) length frequency distribution for sprat recorded by fishermen in Lyme Bay.

Biological information is collected in the acoustic surveys (PELTIC survey) every year in Quarter 4. Length–frequency from PELTIC are shown in Figure 3 and suggests a majority of adults residing in the area.

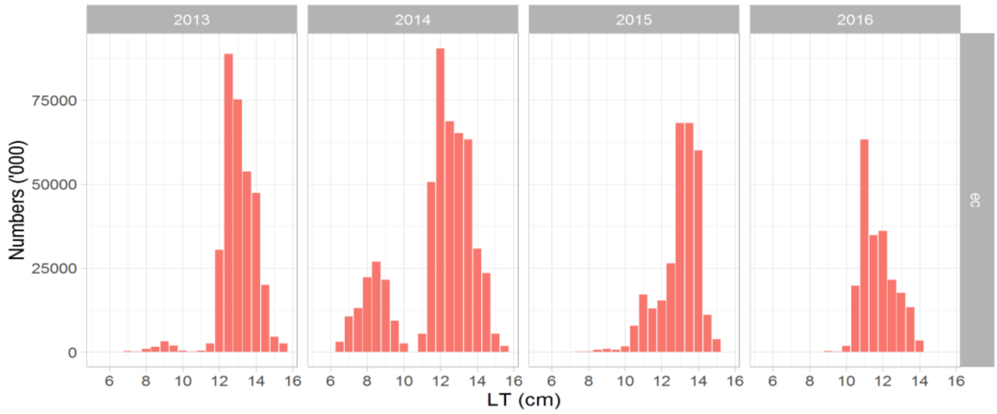

Figure 3. Sprat 7.d-e. Length–frequency distribution from PELTIC survey in Division 7.e.

B.3. Surveys

PELTIC survey

A pelagic survey is undertaken in Autumn in the western English Channel and Eastern Celtic Sea to acoustically asses the biomass of the small pelagic fish community within this area (divisions 7.e–g). The survey follow the design experimented during a pilot study carried out in 2011 and 2012 within a Fisheries Self Sampling (FSP – described below) programme. This survey, conducted from the RV Cefas Endeavour, is divided into three geographically separated regions: the western English Channel, the Isles of Scilly and the Bristol Channel (Figure 4). Since 2017, the survey was expanded to cover also the French part of Division 7.e.

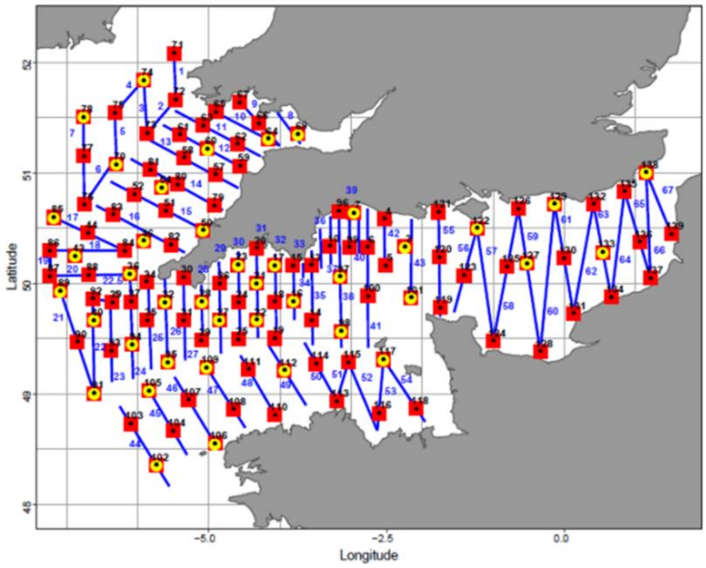

Figure 4. Sprat in 7.d–e. Survey design with acoustic transects (blue lines), zooplankton stations (red squares) and oceanographic stations (yellow circles).

Calibrated acoustic data were collected during daylight hours only over three frequencies (38, 120, 200 kHz) from transducers mounted on a lowered drop keel at 8.2 m below the surface. Pulse duration was set to 0.516 m s for all three frequencies and the ping rate was set to 0.6 s^{-1} as the depth did not exceed 100 m. Data from 38 kHz was used to determine target species abundance for all swim bladder fish. To distinguish between organisms with different acoustic properties (echo types) a multi-frequency algorithm was developed, principally based on a threshold applied to the summed backscatter of the three frequencies, eventually resulting in separate echograms for each of the echo types.

The estimation of biomass and density by age and the associated CV was done using the software StoX. StoX is an open source software developed at IMR, Norway to calculate survey estimates from acoustic and swept area surveys. The program is a standalone application build with Java. Some of the StoX functions can also be implemented in R using the library RStoX. Estimation of abundance with StoX is carried out according to the stratified transect design model developed by Jolly and Hampton (1990).

FSP SURVEY

Acoustic surveys covering the area where the fishery operates were conducted in 2011 and 2012. The surveys are carried out in October, coinciding with the early months of the sprat fishing season, which runs from September to February. The survey included a series of pre-designed parallel, equidistant (10 nautical mile, nmi) transects perpendicular to the coast, covering the ICES rectangles where most of the annual sprat catches in the past decade (Roel *et al.*, 2011) have been made, with particular focus on the western part of Lyme Bay. The pre-designed transects covered a larger area than was feasible, but based on previous experience, it was anticipated that the main sprat concentrations were likely to be found in a relatively small part of the whole area. Given that the location and extent of the sprat distribution was not known in advance of the survey, an adaptive design was adopted, with transects being dropped as the biomass dropped progressively from earlier transects.

A local sprat fishing vessel was chartered for the survey: the 11.98 m RV *Mary Anne*. Although its size restricted its range and speed to some extent, it was imperative to the programme that the survey be conducted using a local fishing vessel experienced in fishing for the target species, i.e. sprat. Also, the aim of the project was to quantify the sprat population targeted by the inshore fishery, and we were confident that the vessel could cover the area of interest adequately.

Acoustic surveying took place during daylight, because sprat disperse into loose aggregations at night (Plirú *et al.*, 2011), so would be more difficult to detect acoustically then. Where possible, the transects were completed from east to west because anecdotal information suggested that sprat move in from the west. Surveying the transects in the opposite direction, therefore, would have increased the likelihood of double counting.

- **2011 FSP design**

Fisheries acoustic data

Scientific quality acoustic data were collected using a portable EK60 Simrad echo-sounder operating at 120 kHz, connected to a Furuno GPS. Ping rate was set to 0.4 s^{-1} and pulse duration to 0.256 μs, to collect high-resolution data. The transducer was attached to an over-the-side mount on the port side of the vessel. The mount consisted of a vertically orientated aluminium pole that, when deployed, protruded 2 m below the surface, so that the transducer remained clear of the bubbles formed by the hull during steaming. A 5 inch fin was attached to the aft side of the pole to prevent vortices developing as a result of the drag through the water; they would cause the pole to vibrate during steaming (see van der Kooij *et al.*, 2011, for more detail).

Prior to the survey, the echo-sounder was successfully calibrated outside Torquay harbour using a 23 mm copper sphere following standard methods (Foote *et al.*, 1987). Depending on weather, the vessel speed during the acoustic transects was a constant 7 knots. Faster than that and in adverse weather, noise would have reduced the quality of the acoustic data.

Acoustic data were recorded continuously. A scanning sonar, traditionally used by the fishery to search for sprat schools, was switched off while running the acoustic transects because it interfered with the acoustic data. When marks were encountered on-transect and a decision made to fish, the vessel would come off-transect and use the sonar to track the schools that had been seen on the echo-sounder. After completion of the haul, the sonar was switched off again, and the transect resumed where it had been interrupted.

The acoustic data were cleaned and processed after the survey using the processing software Echoview version 5.3 (Myriax). Acoustic data collected during fishing operations and the steam to and from the transect were discarded, retaining only on-transect data. Surface aeration caused by bad weather was removed, setting a surface exclusion line, and acoustic data from closer to the seabed than 0.5 m were also removed, to exclude the strong signals from the seabed. Owing to the presence of occasional noise, interference and weaker scatterings caused by other organisms, several algorithms were applied so that only sprat schools were extracted from the raw data. This included a filter to remove all non-clupeid backscatter and a backscatter threshold (of -60 dB; Figure 2). Sprat schools were identified based on a combination of expert knowledge and trawl catches.

As small numbers of other species were caught in the trawl, acoustic energy was partitioned by species, based on the weight ratios obtained from the trawl catches. Mackerel, however, were not considered because they only give a weak signal at 120 kHz and were automatically filtered out using the algorithm mentioned above.

Trawling

Trawling is conducted using the vessel's standard commercial midwater gear designed to catch sprat. As sprat biomass was calculated from the acoustic data, trawl catches were used only to establish the species composition of the acoustic marks, and to collect biological material on the pelagic fish community, in particular length frequency, and age and maturity information. This meant that only relatively small catches were required, so the skipper ensured this by carefully monitoring the trawl procedure using a combination of the sonar and the netsonde.

Once onboard, the catch was sorted by species. Fish were counted and measured to the nearest 0.5 cm or 1.0 cm, depending on species. When catches of a species were very large, a subsample of that species was taken. At every station, however, five sprat from each length category were collected and retained on ice, then once ashore, were frozen and taken on board the RV Cefas Endeavour for further analysis: length, weight, sex and maturity were recorded, and otoliths were extracted for age determination.

Biomass calculation

The acoustic density attributed to sprat (s_A or Nautical Area Scattering Coefficient) was converted into numbers according to standard procedures. First, the TS was calculated for each sprat length group:

$$TS = 20\mathrm{Log}L + b_{20}, \qquad (1)$$

where b_{20} was -74.2 dB at 120 kHz (Saunders *et al.*, 2012), and L was the fish length group. This was converted into the backscattering cross section for each length group:

$$\sigma = 4\pi 10^{(TS/10)}, \qquad (2)$$

This in turn provided the weighted average backscattering cross section per individual fish. Dividing the s_A or the NASC (mean acoustic energy attributed to sprat) per nmi by this number yielded the mean number of sprat per nmi, which was converted into biomass by multiplying by the mean weight of sprat. Because fish weight could not be determined accurately on board the commercial fishing vessel, the mean weight was derived as follows: a length–weight relationship was calculated based on trawl samples in the area obtained from the international bottom trawl survey which takes place in November. The calculated weight of a sprat at a mean length of 13.27 cm was 16.57 g. The biomass was calculated separately for each of the four ICES rectangles covered in the survey.

- **2012 FSP design**

Fisheries acoustic data

Fisheries acoustics were recorded at three operating frequencies (38, 120 and 200 kHz). The transducers were mounted on a drop keel which was lowered to 3.0 m below the hull, 8.2 m below the sea surface, which reduced adverse effects of weather. Pulse duration was set to 0.512 ms for all three frequencies and the ping rate was set to 0.6 pings s^{-1}. At all times on-transect live acoustic data were monitored and when unidentified acoustic marks appeared the trawl was shot where possible to identify these marks.

All three frequency echo-sounders were previously calibrated off Portland. Some issues with noise, that rendered data deeper than ~50 m useless, were solved changing the pulse duration to 1.024 ms, which appeared to improve the range of good data to 70 m.

Acoustic data were cleaned: this operation included the removal of data collected during plankton and oceanographic stations, and fishing operations. Both the on-transect data and those collected during the steam between transects were retained. Only the former was used for further biomass estimates but the inter-transect data were retained and cleaned for future studies on spatial distribution of predators and prey. Surface aeration caused by bad weather was removed by setting a surface exclusion line and acoustic data below 1 m above the seabed were also removed, to exclude the strong signals from the seabed. Large amounts of plankton were present throughout the survey, often represented in layers on all three acoustic frequencies (although at different strengths depending on the organisms). Fish schools and plankton were often mixed and a simple extraction of fish echoes was not possible. Therefore, to distinguish between organisms with different acoustic properties (echo types) a multi-frequency algorithm developed in 2012 was refined to separate echograms for each of the echo types. The echogram with only the echoes from fish with swim bladders was then scrutinised and split into different categories.

Trawling

A heavy-duty 'herring' trawl (20 x 40 m v d K Herring trawl, KT nets) was used to sample the pelagic community for the purpose of validating acoustic marks and collecting biological samples. The trawl was tested and tuned by experimenting with different weights, speeds and warp. A wireless 50 kHz Marport netsonde was mounted on the headrope of the trawl at the mouth of the net, which allowed for live monitoring of the trawling performance. In general, the trawl performed well and caught a broad range of species and size classes. After preliminary tests a GoPro (Hero silver edition) video camera mounted in a 10 000 ft. waterproof housing, was mounted in front of the codend (facing forward) with underwater lighting to monitor fish behaviour in the trawl *a posteriori*.

Fish were sorted to species and size categories before the total catch was weighed and measured using the Cefas EDC system. In the case of very large catches, subsamples were taken before weighing and measuring. The sex and maturity of the pelagic species in each trawl was assessed (ten per length class of mackerel, sprat, sardine, anchovy, horse mackerel, garfish, herring), and their otoliths and stomachs were dissected out and removed for later analysis.

Biomass calculation

The recordings of area backscattering strength (NASC) per nautical mile are averaged over a one nautical mile EDSU, and the allocation of NASC values to mark category for each target species is based on the composition of the trawl catches and the appearance of the echo traces. NASC values are assigned according to scrutinization methods and are used to estimate the target species numbers according to the method of Dalen and Nakken (1983). Note that interconnecting inshore and offshore inter-transects are not included in the analysis.

Total estimates and age and maturity breakdowns are calculated. Biomass is calculated from numbers using length–weight relationships determined from the trawl samples taken during the survey for each of the analysis areas. To estimate the abundance, the allocated NASC values are averaged by stratum within the survey area. For each stratum, the unit area density of fish (SA) in number per square nautical mile (N*nmi-2) is calculated using standard equations (Foote *et al*., 1987; Toresen *et al*., 1998).

The calculation of biomass and abundance from survey data are currently being scripted in R to standardize the processing of survey data and quality control the data during the survey.

IBTS survey

Starting in 2006, the French started to carry out additional tows in the Eastern English Channel as part of the standard IBTS survey in quarter 1. This proved successful and starting in 2007 the RV 'Thalassa' carried out 8 GOV trawls and 20 MIK stations.

During the IBTSWG in 2009, Roundfish Area 10 was created to cover these new stations fished by France and the Netherlands. Data are stored in DATRAS database and available since 2007 (Figure 5).

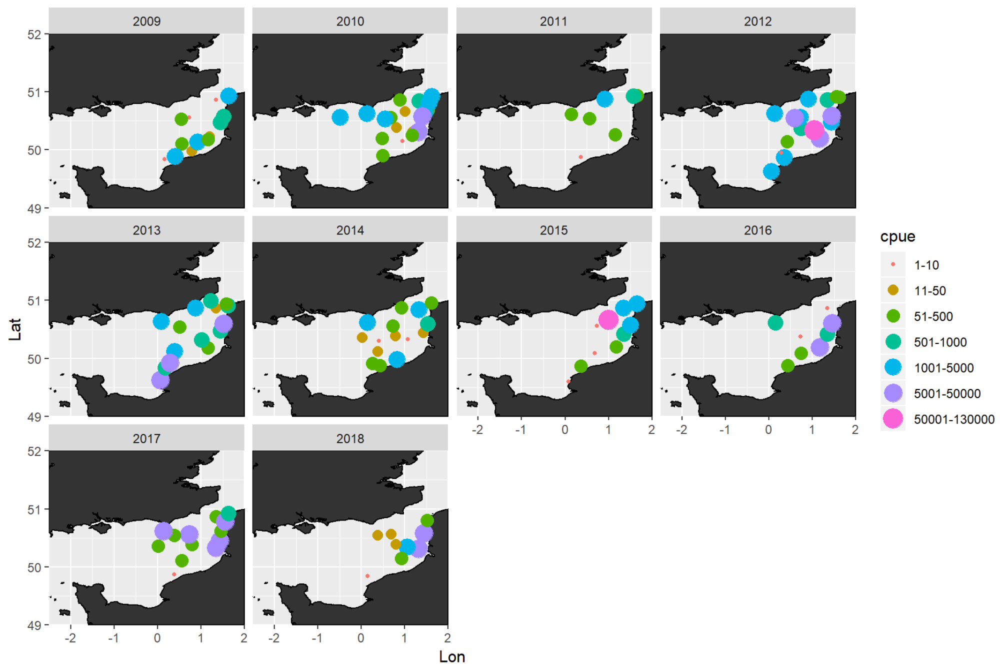

Figure 5. Sprat CPUE from the IBTS survey carried out in area 7.d.

B.4. Commercial LPUE

A midwater trawl landings per unit of effort (LPUE) series were constructed based on vessels that take most of the catch around Lyme Bay. The number of vessels range between 3 and 4 vessels with in each season with the exception of 2005 when only 2 vessels contributed to the LPUE. LPUE is calculated seasonally (August–March) based on the landings per hour away from port until 2016, and on landings per day from 2017 onward for the full timeseries.

Communication with fishermen that target sprat in the Channel has indicated that the fish may not be found on occasions, so if there were no landings in August or March, the effort in those months was excluded when computing LPUE.

C. Assessment: data and method

Assessment is based on trend of total biomass (tonnes) from the PELTIC acoustic survey from 2013 onward. The age range goes from 0 (even though very few age 0 are found in the area at the time of the survey) to age 6+.

The acoustic survey covers a much wider area compared to the one covered by the fishery. The stock identity for sprat in the Channel it is still unclear, but the survey suggests that the stock is mainly located in the English part of Division 7.e. Since 2017, the French part of Division 7.e was covered by the survey and very little sprat (mostly age 0 and 1) was found in the area. An extension of the survey in 2018 to cover Division 7.d found very little sprat compared to area 7.e. Besides, the transects located in the very eastern part of Division 7.e seems to confirm that the sprat stock in the western English Channel do not extend in the Eastern English Channel (Figure 6).

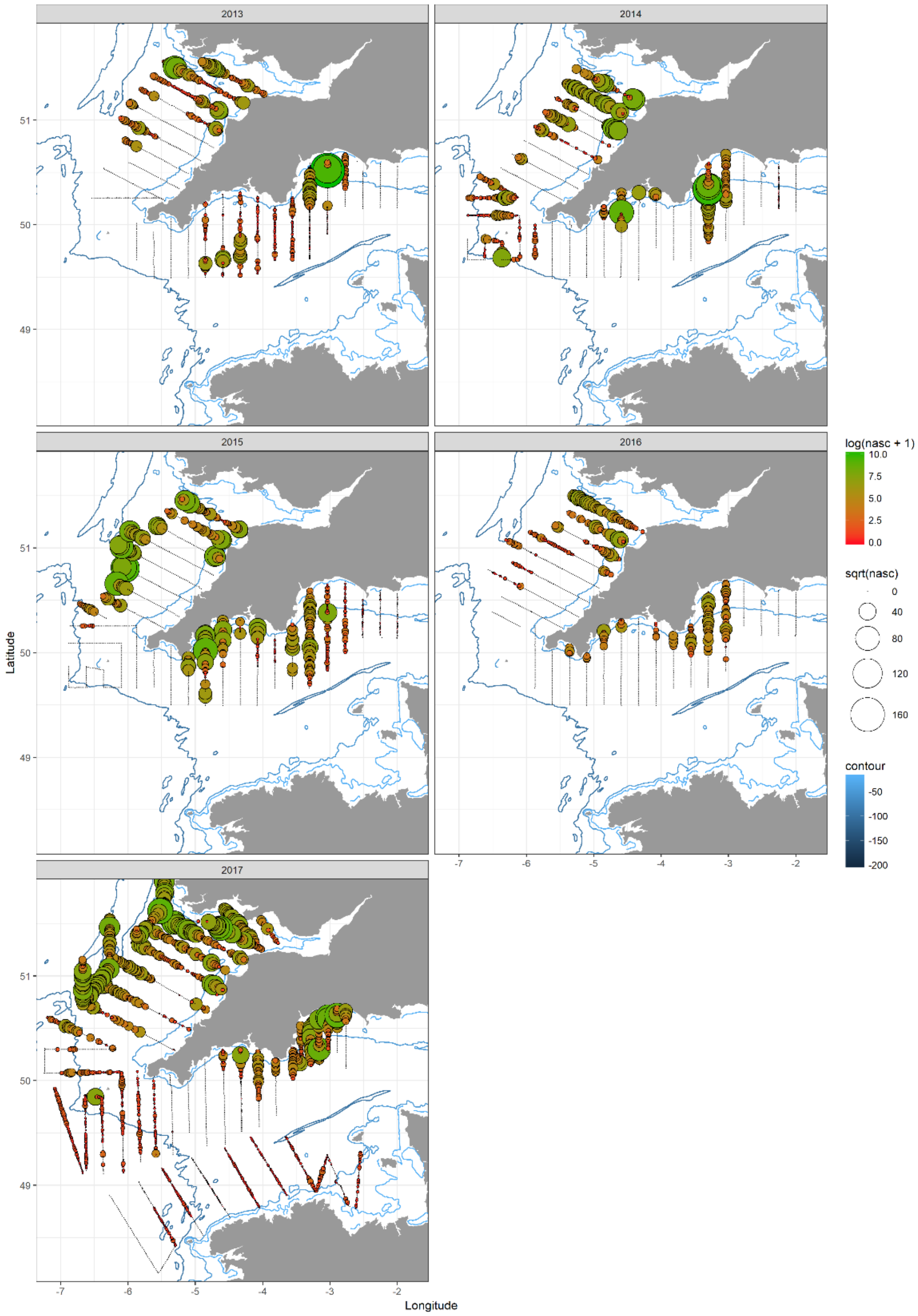

Figure 6. Sprat in 7.d-e. Acoustic backscatter attributed to sprat per 1 nmi equidistant sampling unit (EDSU) during October.

The biomass used for the assessment is calculated over the area shown in Figure 7.

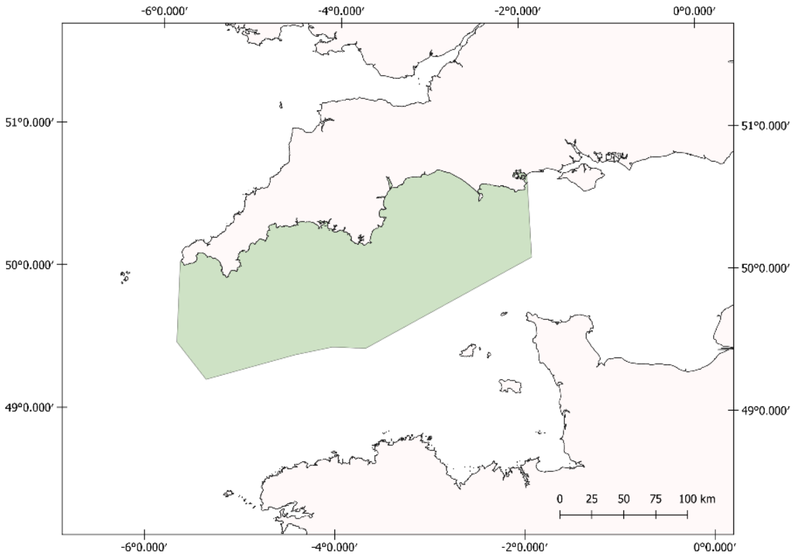

Figure 7. Sprat in 7.d-e. Area covered by the PELTIC acoustic survey used for the calculation of the biomass index used for advice.

Given the seasonal nature of the fishery, the advice is provided on a seasonal basis (1 July–30 June).

C.1. Catch advice

Catch advice is based on ICES framework for category 3 stocks (ICES, 2012) according to the data and analysis that were available. This category includes stocks for which survey indices (or other indicators of stock size such as reliable fishery-dependent indices) are available that provide reliable indications of trends in stock metrics such as mortality, recruitment and biomass.

The index available for this stock is an acoustic survey index which commenced in 2013. It is carried out every year in October and includes the area where the fishery takes place. The availability of this acoustic survey is expected to provide a reliable indication on the status of the stock as it covers most of the fished area and potentially the whole distribution of the stock.

Data and computations

Since the PELTIC acoustic survey covers the area where 90% of the catches occur and it is believed to be representative of the stock biomass in the area, this survey is used as the basis of the advice. The advice is based on the ICES framework for category 3 stocks and is calculated as the average of the two last years of biomass estimates divided by the average of the preceding 3 years estimates and applied to the last ICES catch advice available for sprat in ICES divisions 7.d and e.

A precautionary buffer was last applied in 2017 as stock status in relation to reference points is unknown for this stock.

An evaluation on the appropriateness of the ICES agreed methods for category 3 stocks was carried out during WKSpratMSE using management strategy evaluation simulations (ICES, 2019) the results of which gave a 20% harvest rate as a more precautionary option. However, the option to set catch equal to 20% of the acoustic total biomass (ages 0 to 6+) reported for Division 7.e should be further evaluated before full implementation. As well as the trends in biomass from the PELTIC acoustic survey, the CPUE index from IBTS Q4 survey and the commercial LPUE will also be monitored and compared to support the advice: mainly to assess signs of impaired biomass from either one of the indices, allowing a warning to be issued and additional measures taken.

D. Short-Term Projection

No short-term projections are put forward.

E. Medium-Term Projections

No medium-term projections are put forward.

F. Long-Term Projections

No medium-term projections are put forward.

G. Biological Reference Points

No precautionary reference points are defined for sprat populations in this region.

H. Other Issues

The English Channel sprat stock is primarily defined as sprat living in and caught in Lyme Bay (south coast of England). The geographical limits of the unit stock are unknown and as such the dynamics of the fishery may reflect a small portion of a much large or widespread stock.

H.1. Historical overview of previous assessment methods

ICES has started to give quantitative advice for this data-limited stock in 2012.

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