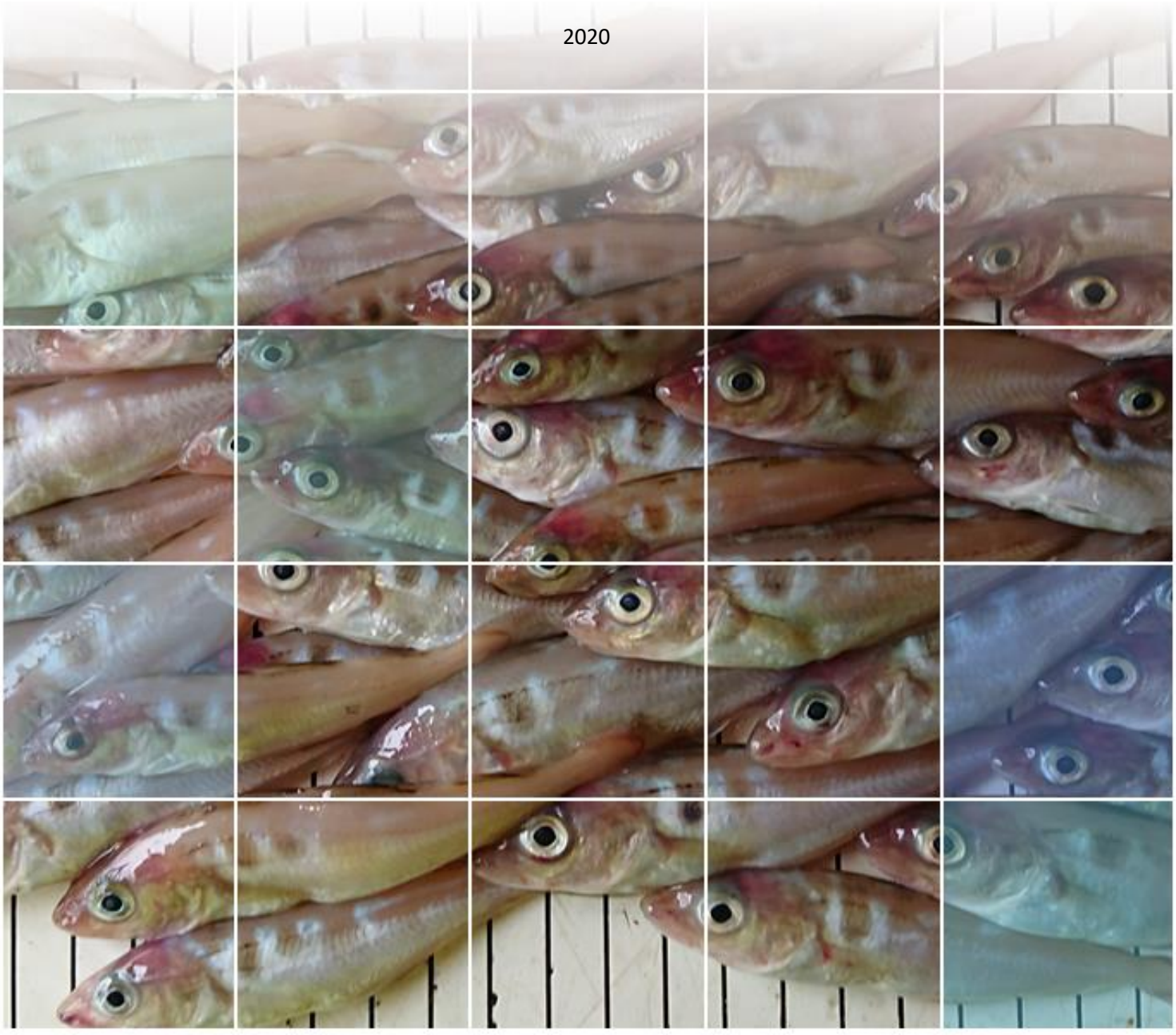
NAFC Marine Centre
University of the Highlands and Islands

Overview of annual Shetland trawl survey data (2011 - 2020): catch rates and size compositions of commercial demersal fish species in nearshore waters

Shaun Fraser, Chevonne H. Angus, Connor Wood, Kirsty Laurenson

2020



Overview of annual Shetland trawl survey data (2011 - 2020): catch rates and size compositions of commercial demersal fish species in nearshore waters

Authors:
Dr Shaun Fraser, Dr Chevonne H. Angus, Connor Wood, Kirsty Laurenson

2020 survey team:
Arthur Johnson, Sean Williamson, Dr Shaun Fraser, Connor Wood, Kirsty Laurenson

Corresponding author:
Dr Shaun Fraser
Email: shaun.fraser@uhi.ac.uk

NAFC Marine Centre
Port Arthur
Scalloway
Shetland
ZE1 0UN
Tel: 01595 772000
Web: www.nafc.uhi.ac.uk

The data described in this report are available on request from the corresponding author.

Suggested citation: Fraser, S., Angus, C.H., Wood, C., and Laurenson, K. (2020). Overview of annual Shetland trawl survey data (2011 - 2020): catch rates and size compositions of commercial demersal fish species in nearshore waters. *NAFC Marine Centre report*. pp 18.

Contents

Executive summary

An overview of results from annual trawl surveys conducted by the NAFC Marine Centre from 2011 - 2020 of the coastal waters around the Shetland Islands is presented. The purpose of the surveys was to provide independent information on the distribution, relative abundance, and population structure of fish species in local waters. Key results from the available data are reported here with a focus on commercially important species. This report is intended for a general audience with information presented in a concise and non-technical format.

The surveys have been carried out annually using the 12 m MFV *Atlantia II* (LK 502) during August and September, using a standardised survey trawl fitted with a small-mesh (20 mm) cod-end. The annual inshore fish survey involved hauls from 27 pre-defined locations within 12 nautical miles of Shetland. Since 2017, a concurrent shallow fish survey has also been undertaken with 25 hauls targeting potential nursery grounds around the coast of the Shetland Islands. Catch rate results were used to investigate the relative abundance of commercial species by considering catch per unit effort (CPUE). Length data were used to further interpret variations in population structure and recruitment.

Results are presented for the 12 most significant commercially important demersal fish species sampled throughout the surveys. Key findings from the 2020 surveys include:

- The highest haddock (*Melanogrammus aeglefinus*) catch rate (by weight) recorded since the surveys began was observed on inshore grounds and linked to consistently high catches of haddock just below marketable size.
- Similarly, high catches of whiting (*Merlangius merlangus*) were observed on inshore grounds leading to the highest relative abundances of marketable whiting recorded since the start of the surveys.
- In contrast, cod (*Gadus morhua*) catch rate (by weight) followed the declining pattern observed since 2017 and was related to relatively fewer numbers of larger marketable fish present in inshore catches.
- Shallow survey length data indicated that shallow waters around the coast of the Shetland Islands can be considered nursery areas for a variety of commercial species, with substantial numbers of small cod, haddock, plaice (*Pleuronectes platessa*), whiting, and monkfish (*Lophius* spp.) recorded again this year.

Final points of this report include suggestions for further analyses and the recommendation that the annual inshore and shallow fish surveys are continued.

1 Introduction

The provision of accurate data for analyses makes effective field sampling essential for understanding marine environments. The management of demersal fisheries resources requires data on the distribution and relative abundance of the fish species present on or just above the seabed. Understanding the dynamics and population structure of target species also requires further biological information.

Data from commercial fisheries are key components of stock assessments for many locally important species. However, the behaviour of individual fishing vessels targeting specific catches and using different gear configurations can bias commercial data. Such effects must be considered when interpreting fisheries dependent data. Therefore, independent data from scientific fisheries surveys are an important additional source of information and annual surveys can be used to build valuable time series for investigating the dynamics of fish communities and for informing the management of fish stocks.

On a regional scale the International Bottom Trawl Survey Working Group (IBTSWG) coordinates international survey programmes for the International Council for the Exploration of the Sea (ICES). These programmes include annual fisheries-independent surveys in the North Sea and Northeast Atlantic which use a fleet of large vessels from multiple countries to collect data from hundreds of hauls. However, the spatial resolution of these surveys is limited by the large areas that require to be covered and as a result usually only two 30 minute hauls are undertaken in each approximately 30 x 30 nautical mile statistical rectangle. Consequently, a smaller-scale survey using a vessel capable of sampling nearshore areas is beneficial for monitoring local temporal and spatial trends.

An annual fish survey has been undertaken in the waters around the Shetland Islands by the NAFC Marine Centre since 2011. This survey was originally initiated in response to fishermen reporting high abundances of small cod on inshore fishing grounds. Standardised trawling gear and fishing methods have been used in order to provide an independent index of the nearshore distribution and relative abundance of demersal fish species. By repeating the survey each year, the resulting data have become increasingly valuable for determining the inter-annual variability of nearshore fish catch rates. Since 2017, these data have been further enhanced by an extended survey design which targets potential nursery grounds in shallow areas to collect additional information on juvenile fish (i.e. those smaller and younger fish yet to reach sexual maturity).

The catch from each survey haul provides information on which species are present at that location and in what quantities, as well as the size compositions of key species. Size information is used to infer population structure and to indicate the strength of particular year-classes (i.e. those fish born in any one year) which can reveal variations in recruitment (i.e. the number of fish surviving to enter the commercial fishery or to some life history stage). Young individuals yet to be recruited to the fishery can be captured using scientific trawl gear utilising small mesh sizes. Consequently, scientific trawl data provide important information on juvenile abundances which is not available from commercial landings due to the commercial restrictions on landing sizes and gear design.

The use of standardised survey methods is essential to ensure that any changes in catches through time accurately reflects variability in the composition of demersal fish communities. The efficiency of trawling gear at catching fish is species-dependent, and so trawl surveys typically provide relative estimates rather than information on absolute abundances. Multiple hauls across a range of areas enables more robust estimates to be made and the variability of results to be quantified.

This report provides an overview of key results from the available survey data collected from 2011 to 2020. The focus of this report is on information for marketable demersal species which are most significant to the local mixed whitefish fishery. Results are presented in a concise and non-technical format aimed at being accessible to all those involved in fisheries and the general public. The purpose of this report is to: (1) provide an up-to-date and independent source of information on the present relative abundance and recruitment of commercially important fish species in the nearshore waters around the Shetland Islands; and (2) to contextualise these results within the inter-annual trends in catch rate and size composition from the previous nine continuous years of survey data.

2 Materials and methods

2.1 Survey design

Inshore fish survey

The inshore fish survey has been carried out each year since 2011 during August and September around the coast of the Shetland Islands up to 12 nautical miles from shore. The inshore survey was designed to target known fishing grounds over a range of depths (approximately 50 – 150 m). In the first year, the locations of 21 survey tows were defined. In subsequent years, further tows were defined so that the full inshore survey now includes 27 set locations (Figure 1).

Shallow fish survey

Since 2017, a shallow fish survey has been undertaken concurrently to the inshore fish survey during August and September to target potential nursery grounds. The shallow survey was designed to follow a similar coverage around the Shetland Islands to the inshore survey but on comparatively shallow grounds (approximately 20 – 50 m). The current shallow survey comprises 25 tows (Figure 1) which were intended to provide data for comparison to the inshore survey results. Tow duration was variable in the shallow survey, ranging from approximately 0.2 – 1 hr (average is 0.6 hr), due to the limited ground available in most shallow areas.

2.2 Data collection

Survey work was conducted by NAFC Marine Centre staff aboard the 12 m MFV *Atlantia II* (LK 502). The survey gear was based on a standard four-panel box trawl with a headline length of 23 m and a fishing circle of 400 (160 mm) meshes. The cod end was fitted with a small-mesh (20 mm) inner net. The trawl doors used were Bison No. 6½ (Edwin Ashworth Ltd., York) and the sweeps comprised of 37 m of doubles and 55 m of singles.

The gear was towed at approximately 2.5 knots with tow duration defined by the time from when the doors and net were on the seabed until when the trawl winch was engaged to haul the gear. Door spread and trawl headline height were monitored using a Notus net monitoring system. At each location, a towing duration of 1 hr was used whenever operationally possible.

The catch from each haul was first sorted then weighed by species. For commercially important species the individual fish total lengths were measured. Subsampling for length measurements was necessary in some hauls for species caught in particularly high abundances, in which case a random

subsample was taken and its weight measured. Hauls which were potentially affected by damage to the gear or operational problems were invalidated and excluded from analysis. Invalidated hauls were repeated when possible.

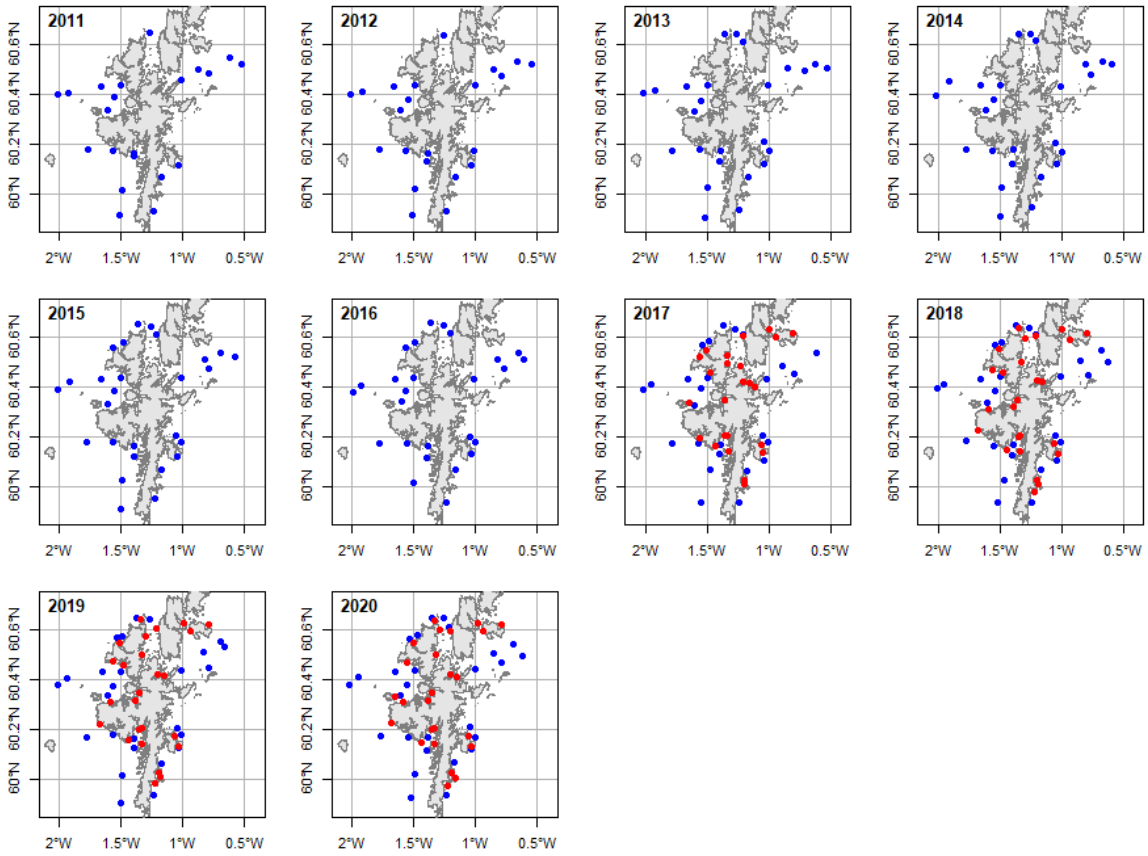


Figure 1. The locations of inshore (blue) and shallow (red) fish survey haul locations shown by year. Each location shows the approximate mid-point of each valid haul.

2.3 Data analysis and interpretation

The analysis here was restricted to the main commercially important demersal fish species present throughout the surveys. Selected species were:

- Cod (*Gadus morhua*)
- Haddock (*Melanogrammus aeglefinus*)
- Plaice (*Pleuronectes platessa*)
- Whiting (*Merlangius merlangus*)
- Monkfish (*Lophius* spp.)
- Lemon sole (*Microstomus kitt*)
- Thornback ray (*Raja clavata*)

- Cuckoo ray (*Raja naevus*)
- Spotted ray (*Raja montagui*)
- Hake (*Merluccius merluccius*)
- Saithe (*Pollachius virens*)
- Megrim (*Lepidorhombus whiffiagonis*)
- Witch (*Glyptocephalus cynoglossus*)
- Ling (*Molva molva*)
- Turbot (*Scophthalamus maximus*)

In order to provide an index of relative abundance for each species the catch rate was considered. Catch rate is expressed as the catch per unit effort (CPUE) which is calculated per species for each haul by dividing the catch by the tow duration. While catch is generally quantified in terms of weight, this approach is less sensitive to hauls with high numbers of undersize fish which may be of interest when considering future recruitment to the fishery. Consequently, CPUE was considered both in terms of weight (i.e. kg / hr) and in terms of the number of individual fish (i.e. number / hour). The average CPUE was calculated across all hauls in each year, and the variability between hauls was quantified by the standard error of the mean.

The size compositions of catches were investigated in more detail by considering length frequency distributions. For the above species, the total number (count) of individual fish in each 1 cm length class was calculated for each haul and corrected for subsampling when necessary then summed over each year. Peaks in length frequency distributions can indicate a specific year-class, the age of which was inferred by using established age-length relationships for the species.

3 Results

Results are arranged by species in approximate order of overall contribution by weight to inshore survey catches. Results from both the inshore and shallow fish surveys are coloured and superimposed to aid comparisons. From some species, low abundances (e.g. turbot) or very high variability between hauls (e.g. saithe) limit the scope for meaningful analyses but these results are included for completeness and to form a baseline of data for future studies.

3.1 Catch rates by weight

CPUE results by weight are presented in Figure 2. The primary overall components of the 2020 marketable inshore catches were haddock, whiting, and plaice; followed by lemon sole, monkfish and cod. Skate species also formed a substantial portion of catches, particularly cuckoo and thornback rays. Other commercial demersal species formed a relatively small component of overall catches.

For most species, catch rates in the areas sampled by the shallow survey were less than results from the inshore survey. Some species which were regularly present in inshore survey results were absent in the 2020 shallow survey (hake, megrim, witch, and ling). In contrast, catches of thornback rays and plaice were markedly higher in the 2020 shallow survey results compared to the inshore survey, while CPUE by weight results for other skate species and monkfish were more similar between surveys.

Notably, in 2020 the catch rates (kg / hr) of both haddock and whiting were the highest recorded since the survey started in 2011. For haddock in particular, these high catches in 2020 were observed consistently across the inshore survey hauls as indicated by the relatively small standard errors, while high whiting catches were somewhat more sporadic. In contrast, inshore cod catches in 2020 indicated that the declining trend in CPUE by weight since 2017 has continued this year resulting in the lowest catch rate (kg / hr) since the start of the survey. For many other species, catch rate results in 2020 were within the range and standard errors of results from previous years. Large standard errors indicate high variability between hauls, which was observed in species such as saithe and often coinciding with years of higher catch rates.

The shallow survey CPUE (kg / hr) results for 2020 reflect recent trends in the inshore survey results in many cases. When considering catch results by weight the potential contribution of smaller fish in nursery grounds is more likely to be obscured, and so these results are investigated in more detail by considering CPUE results by number in the following section.

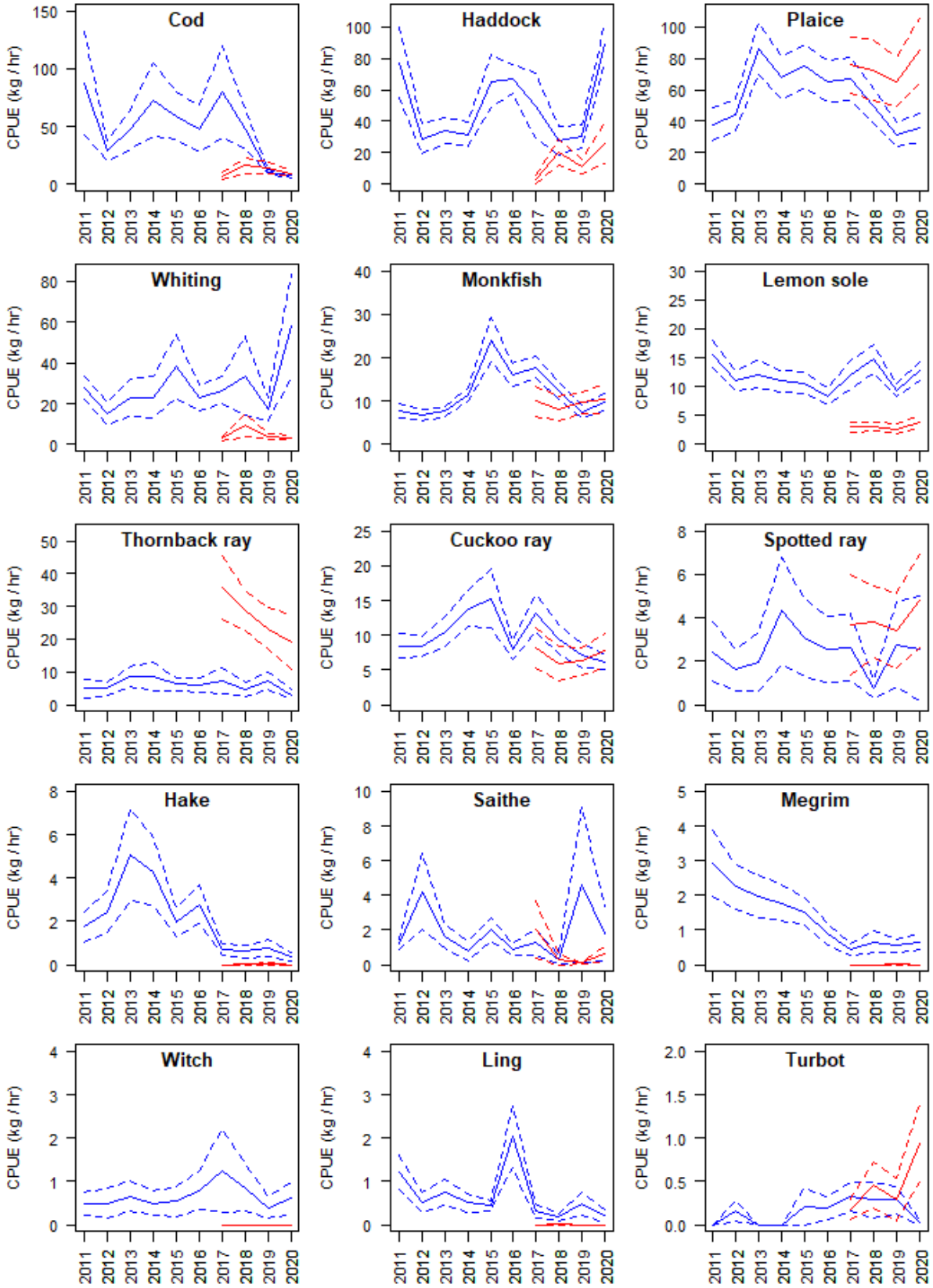


Figure 2. Catch per unit effort (CPUE) by weight for the inshore (blue) and shallow (red) fish surveys. For each year of available data the mean result for all valid hauls is shown (solid lines) with the variability between hauls indicated by the standard error (dashed lines). **How to interpret: these results show the changes in average catch rates in weight (y-axis) from 2011 to 2020 (x-axis) for each selected species.**

3.2 Catch rates by number

Catch rates by number of individual fish are presented in Figure 3. The general patterns of these catch rates are similar to the results in Figure 2 in most cases. Where there is a divergence in trends between Figure 2 and Figure 3 it indicates a substantial change in the overall size composition of that species.

For many species, the 2020 inshore survey CPUE by number results fluctuate within the range and standard errors of results from previous years. Inshore survey results for haddock in 2020 are similarly high to the numbers per hour observed in 2018, but with substantially less variability between hauls in 2020. Plaice results indicate potential reversal of a declining trend in CPUE by numbers on inshore grounds over recent years.

This year's shallow survey results for haddock and whiting numbers appear to be similar to last year. Monkfish mean CPUE by number in the 2020 shallow survey slightly exceeds 2019, which was previously the highest relative abundance yet observed. As in previous years, 2020 results for plaice, monkfish, and thornback ray indicate higher relative abundances in the shallow survey compared to the inshore survey. This is the first year where cuckoo ray results indicate higher mean CPUE results in the shallow survey compared to the inshore survey, with inshore survey results indicating a decline in numbers since 2017. Very few hake and ling were observed this year. Cod catches by number for 2020 are notably higher in the shallow survey results than in the inshore survey results, suggesting that relatively high numbers of small cod were present on shallow grounds this year, despite low overall catch weights.

To understand how the size composition of species has varied in more detail, length frequency distributions are examined in the following section.

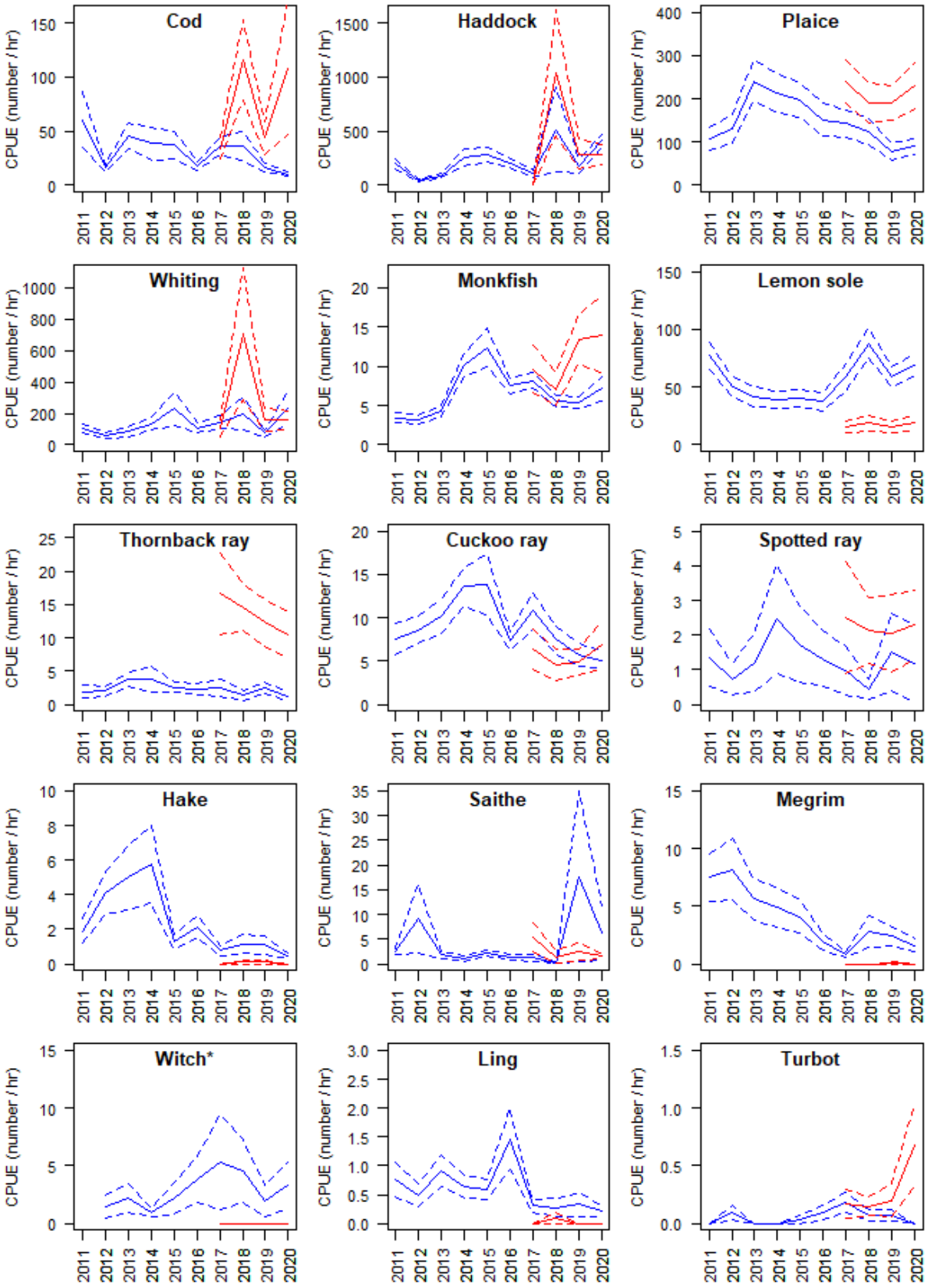


Figure 3. Catch per unit effort (CPUE) by number for the inshore (blue) and shallow (red) fish surveys. For each year of available data the mean result for all valid hauls is shown (solid lines) with the variability between hauls indicated by the standard error (dashed lines). *Note that results for witch in 2011 are omitted due to unrecorded data. **How to interpret: these results show the changes in average catch rates in numbers of individual fish (y-axis) from 2011 to 2020 (x-axis) for each selected species.**

3.3 Size compositions

The overall size composition results from the available fish length data for each year are presented in Figure 4 to Figure 8. These results are interpreted in relation to changes in the population structure of the selected species in the shallow and inshore fishing grounds.

Cod length results demonstrate a relatively high variability in size composition over time (Figure 4). A particularly high number of undersize (< 35 cm) cod were recorded during the inshore survey during 2013 and, to a lesser extent, in 2017. Decreasing numbers of marketable cod are evident in inshore survey results in recent years. The small peak at approximately 30 cm observed in 2019 inshore cod catches is also present in a reduced form this year. The 2020 shallow survey results for cod contrast clearly with the inshore survey results and show high numbers of small cod below the length range observed in inshore data and peaking at 13 cm. This peak in small cod on shallow grounds in 2020 is interpreted as evidence of age-0 cod (i.e. cod less than 1 year in age) and was of much higher magnitude than the corresponding peak observed last year and of a similar overall magnitude to the high numbers observed in 2018.

The size composition of haddock catches (Figure 4) in both the inshore and shallow surveys indicates highly intermittent recruitment. Strong haddock year-classes can be followed over successive years, such as in 2014 where the clear peak in small haddock centred at 13 cm (age-0) can be followed to 26 cm (age-1) in 2015 and then at 35 cm (age-2) in 2016. The high peak in inshore catches observed this year centred around 27 cm represents an especially high relative abundance of haddock just below marketable size. Shallow survey results for haddock show a similar age-0 peak to last year with a further substantial peak in the same length region as the inshore results.

Inshore results for plaice indicate a relatively stable size structure over time, peaking at approximately 30 cm (Figure 4). Comparing the shallow and inshore plaice results for 2020 indicates a very similar population structure with slightly higher numbers of undersize plaice recorded in shallow catches but with no clear indication of the additional peak at approximately 20 cm observed in 2019 shallow data.

Whiting size structure results (Figure 5) follow a similar pattern in 2020 to previous years with the shallow survey results characterised by a distinct peak of age-0 fish at 10 cm of similar magnitude to the previous year. The 2020 inshore whiting results indicate a strong peak at 30 cm resulting in the highest relative abundances of marketable whiting recorded since the start of the surveys.

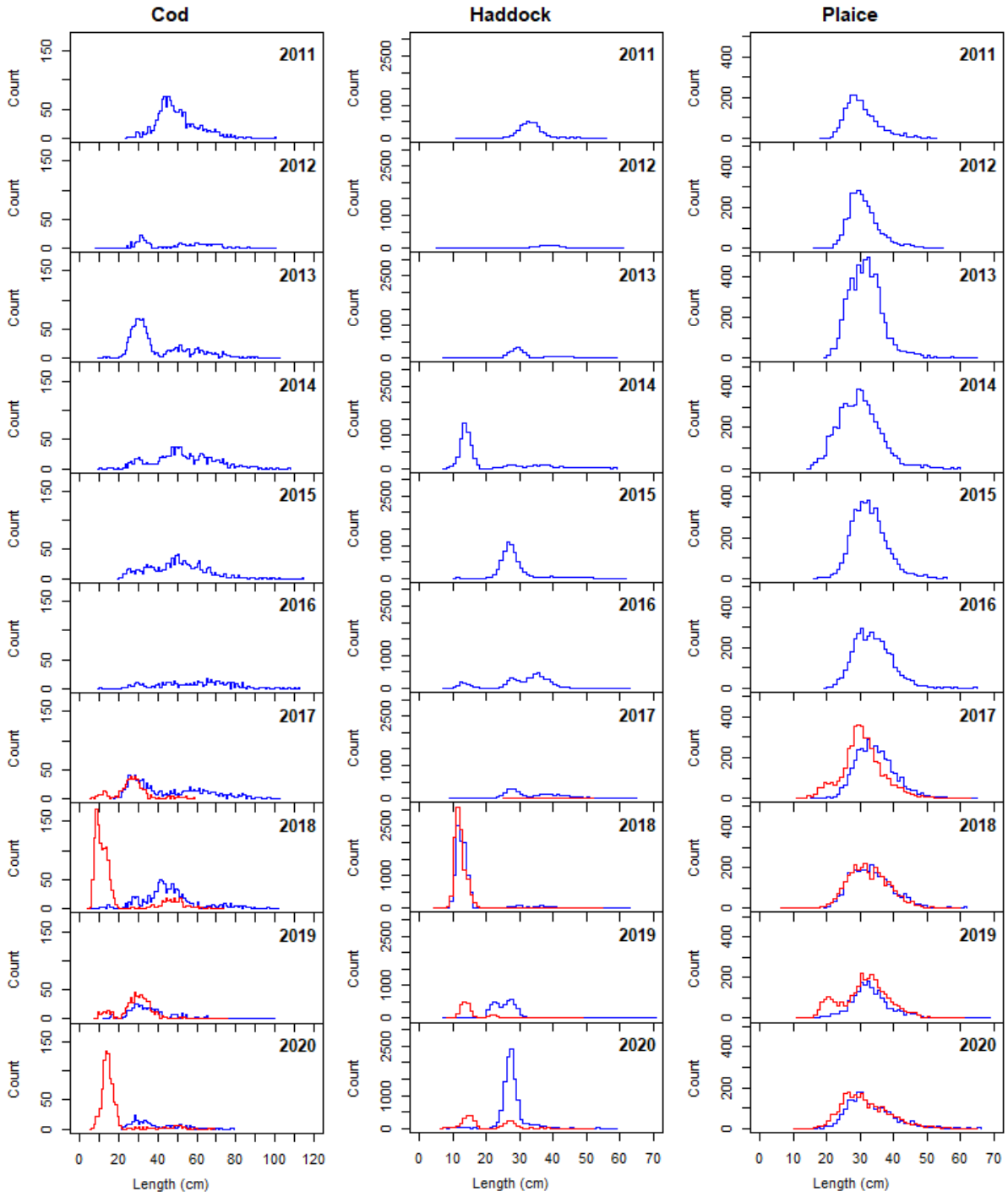


Figure 4. Length distribution results showing the total number (count) of individual fish in each 1 cm length class caught during the inshore (blue) and shallow (red) fish surveys. **How to interpret: these results show the numbers of individual fish (y-axis) of each species in every 1 cm size category (x-axis) during each survey year.**

The monkfish length data (Figure 5) indicate a variable pattern through time and the presence of outliers over a relatively wide length range. As in previous years, the 2020 monkfish results indicate a higher relative abundance of small fish on the shallow grounds with a peak at approximately 30 cm, compared to the inshore survey results where larger fish were observed in greater numbers.

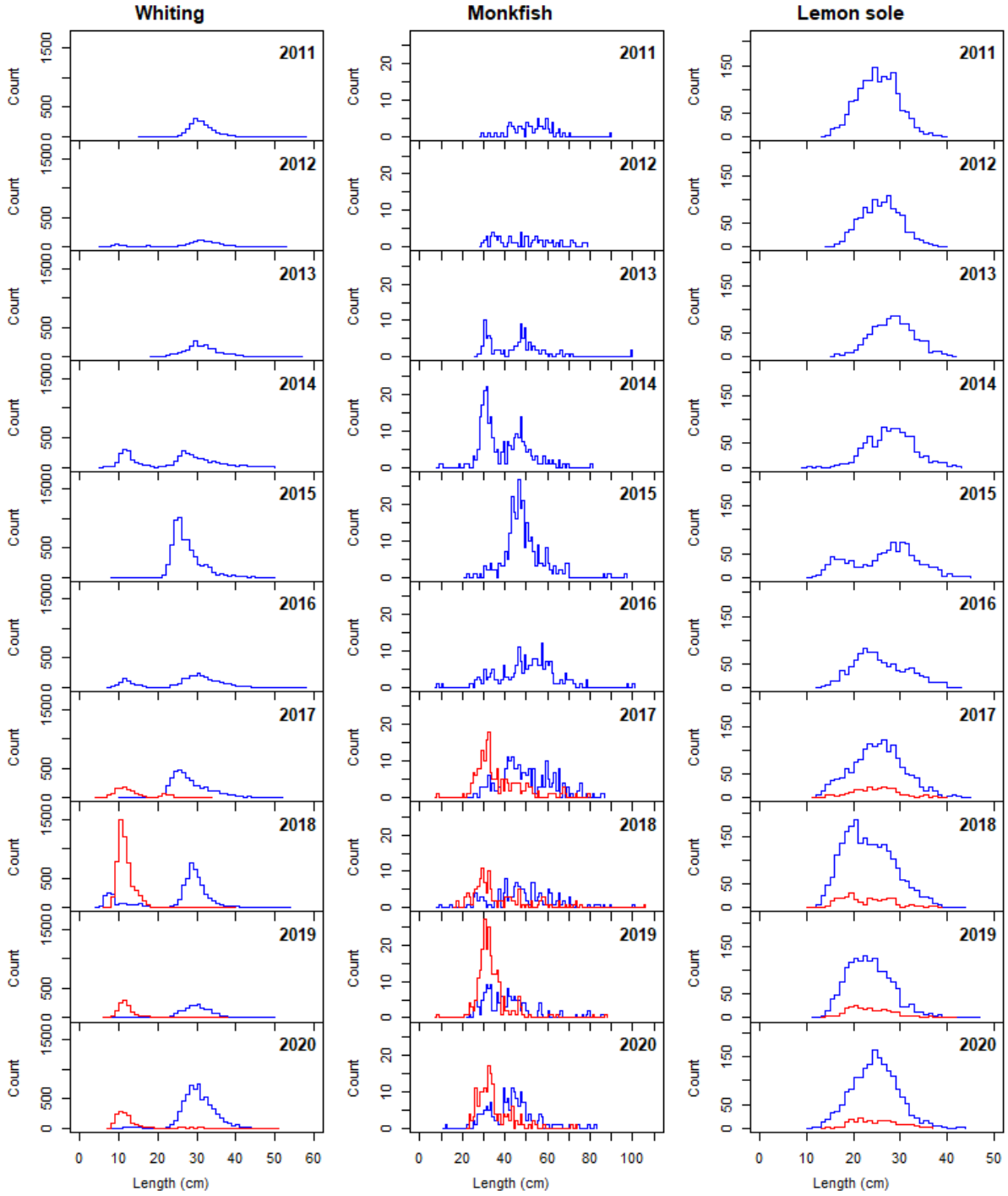


Figure 5. Length distribution results showing the total number (count) of individual fish in each 1 cm length class caught during the inshore (blue) and shallow (red) fish surveys.

The lemon sole data (Figure 5) show a relatively stable size composition in recent years which is approximately similar in shape for the inshore and shallow surveys despite the lower relative abundances indicated in shallow grounds. There is no indication of distinct year classes in the 2020 data and the increase in inshore lemon sole CPUE since 2019 appears to be due to relatively higher numbers of fish in the range 23-31 cm.

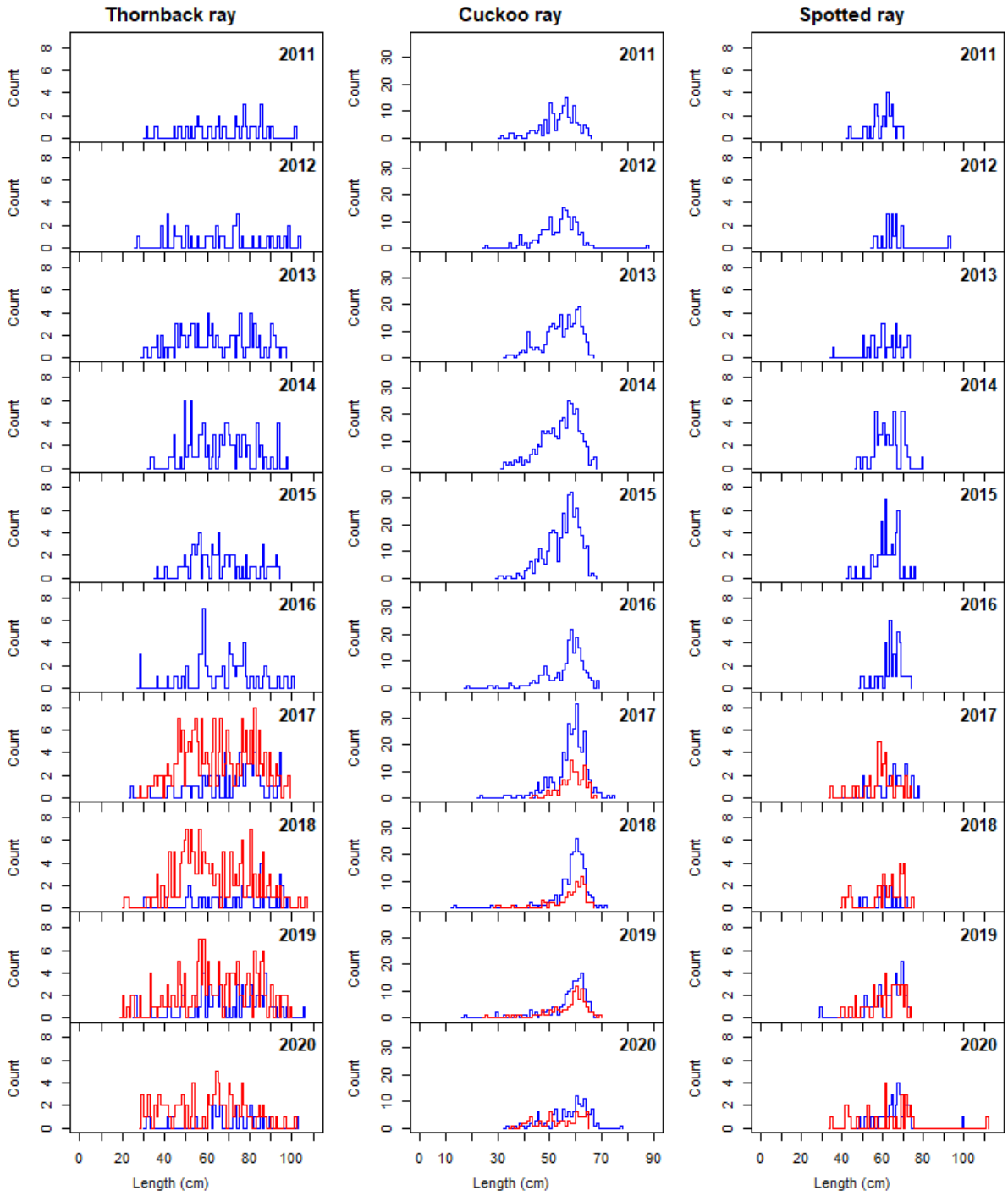


Figure 6. Length distribution results showing the total number (count) of individual fish in each 1 cm length class caught during the inshore (blue) and shallow (red) fish surveys.

Length results for thornback ray in 2020 follows a similar pattern to previous years with data recorded over a wide length range in both surveys (Figure 6). Cuckoo ray results show a negatively skewed distribution with a peak in the inshore survey at around 60 cm as in previous years, but less defined shallow results this year. Spotted ray abundances are relatively lower than the previous species with 2020 results characterised by a particularly large outlier in the shallow data measuring 111 cm.

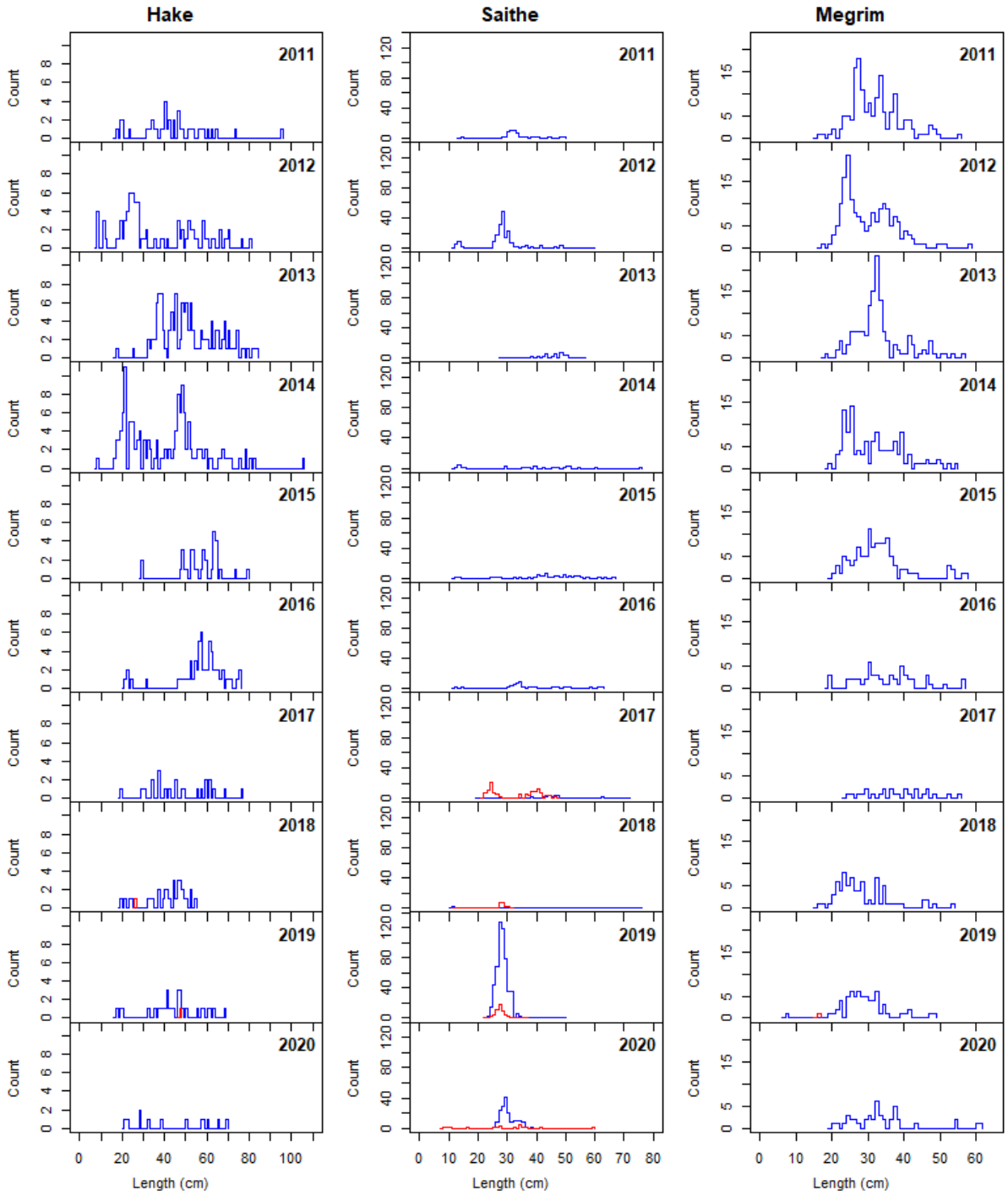


Figure 7. Length distribution results showing the total number (count) of individual fish in each 1 cm length class caught during the inshore (blue) and shallow (red) fish surveys.

The length data for hake, saithe, and megrim (Figure 7) show high variability over the survey years. The few hake observed on inshore grounds in 2020 were present over a relatively wide length range. The 2020 peak in saithe numbers is centred at 29 cm in inshore results while fewer saithe were caught on shallow grounds over a wider length range. The megrim results in 2020 were similar to those from recent years with most inshore catches in the range 20-40 cm.

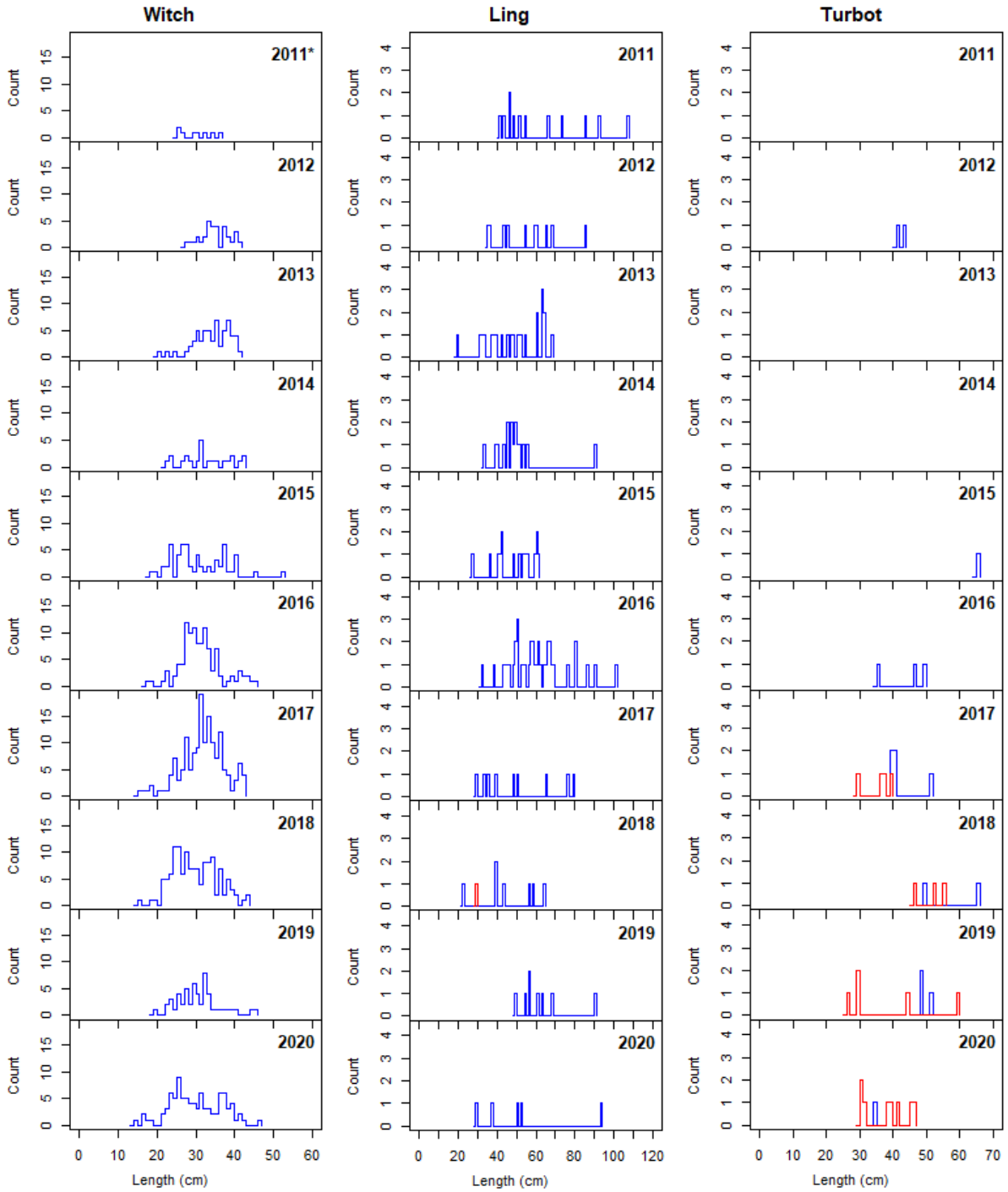


Figure 8. Length distribution results showing the total number (count) of individual fish in each 1 cm length class caught during the inshore (blue) and shallow (red) fish surveys. *Note that length data for witch in 2011 were unrecorded for some hauls.

Witch results in 2020 indicate a broad peak between 20 – 40 cm with some outliers as in previous years (Figure 8). The few ling caught during the inshore surveys are over a range of size classes but in abundances too low to enable much interpretation of population structure (Figure 8). Turbot were present again in both shallow and inshore grounds in 2020, this year over a more limited length range than in some recent years.

4 Discussion

Variations in the catch rates and size structure of commercial fish species around the Shetland Islands have been presented which summarise the 10 continuous years of annual survey data now available. As the temporal and spatial coverage of survey data has improved, trends and patterns in the relative abundance and distribution of locally important fish species can be investigated in increasing detail.

A notable feature of previous survey results was the relatively high numbers of small haddock and whiting recorded in 2014, which was attributed to relatively strong 2014 year-classes of these species. Survey results in the following years confirm that the increase in juvenile fish during 2014 was associated with relatively high catch rates in 2015 and (in the case of haddock) 2016. Such results indicate the utility of a survey of this scale and provides evidence that the methods used here can detect the strength of incoming recruitment from juvenile year-classes which can be followed through subsequent years.

The availability of shallow survey data since 2017 has provided further valuable insights into the spatial distribution and population structure of some key species. In particular, the numbers of smaller plaice, haddock, monkfish, cod, and whiting in the shallow survey data exceeds catches in the inshore survey data which suggests that shallow areas around the coast of the Shetland Islands may be important nursery areas for these commercially important species. Shallow areas were also shown to have greater commercially exploitable abundances of some species, notably thornback ray. In contrast, the shallow survey data show that some species are recorded in relatively low abundances in shallow areas (e.g. lemon sole) or are completely absent (e.g. witch) which highlights the variation in environmental preferences among the selected species.

For many of the species considered here, this year's results were within the range of previous observations. However, the 2020 inshore survey results indicated the highest catch rate (by weight) so far recorded since 2011 for both haddock and whiting. The consistent inshore haddock catches were dominated by a large peak centred at around 27 cm length, indicating high relative abundances of haddock just below marketable size. In the case of whiting, the high inshore catches are associated with the highest relative abundances of marketable whiting yet recorded since the start of the surveys. Shallow survey data for both haddock and whiting indicate distinct and substantial groups of age-0 fish in shallow grounds this year, similar in size composition to the juvenile catches of these species in 2019 which preceded the high catches this year.

Another notable result of the 2020 inshore survey is the relatively low catches of cod. This result indicates that the declines in cod catch rates since 2017 has continued this year. As in 2019, these lower cod catches appear to be related to reduced numbers of larger marketable fish. In contrast, the shallow survey results for cod indicated relatively higher numbers of small age-0 cod on shallow grounds much greater than the corresponding peak observed last year.

The recruitment of gadoid species (which includes haddock, whiting, and cod) is known to be highly sensitive to random variations in environmental conditions and other factors. Haddock stocks in particular are well known to oscillate significantly in year-class abundances with periods of very good recruitment associated with significant increases to the overall stock. Although the future survival rates of undersize fish are unknown, given the results from previous years it seems likely that strong recruitment to the local commercial fishery will be observed soon for species such as haddock and that increased relative abundances may again be detectable in larger length classes in future surveys.

It is recommended that a more comprehensive analysis of these results is undertaken to support the overview presented here. Results on non-commercial fish species are not reported here but could provide additional insights on various important prey species, and the overall local marine ecosystem. An analysis of spatial distributions is also recommended, which could explore trends with area and depth. A more rigorous statistical treatment of these data would enable the significance of results to be investigated in more detail. The increasing temporal coverage of the annual trawl survey data provides additional opportunities for comparison to data from international surveys and local studies to investigate the interactions of species and associations with environmental characteristics.

The timely reporting of the data presented here should support the value and practicality of the inshore and shallow fish surveys to fisheries management organisations and local industry bodies. Future continuity of the annual trawl surveys around the Shetland Islands is recommended which would add value to the extensive dataset already collected and contribute to a comprehensive long-term understanding of the dynamics of inshore demersal fish communities.

Acknowledgements

Thanks to the many contributors, both past and present, to survey work aboard the MFV *Atlantia II* and to data management at the NAFC Marine Centre. Financial support from the Shetland Islands Council and the Shetland Fish Producers Organisation is gratefully acknowledged.