SCALLOP ASSESSMENT WORKING GROUP (WGSCALLOP)

VOLUME 2 | ISSUE 111

ICES SCIENTIFIC REPORTS

RAPPORTS SCIENTIFIQUES DU CIEM

ICES INTERNATIONAL COUNCIL FOR THE EXPLORATION OF THE SEA
CIEM CONSEIL INTERNATIONAL POUR L'EXPLORATION DE LA MER

International Council for the Exploration of the Sea
Conseil International pour l'Exploration de la Mer

H.C. Andersens Boulevard 44-46
DK-1553 Copenhagen V
Denmark
Telephone (+45) 33 38 67 00
Telefax (+45) 33 93 42 15
www.ices.dk
info@ices.dk

ISSN number: 2618-1371

ICES Scientific Reports

Volume 2 | Issue 111

SCALLOP ASSESSMENT WORKING GROUP (WGSCALLOP)

Recommended format for purpose of citation:

ICES. 2020. Scallop Assessment Working Group (WGSCALLOP).
ICES Scientific Reports. 2:111. 57 pp. http://doi.org/10.17895/ices.pub.7626

Editor

Lynda Blackadder

Authors

Lynda Blackadder • Isobel Bloor • Adam Delargy • Helen Dobby • Mairi Fenton • Spyros Fifas • Eric Foucher • Ellen Grefsrud • Jónas Jónasson • Shona Kinnear • Claire Lambden • Andy Lawler • Carrie McMinn • David Palmer • Dave Rudders • Michael Sheridan • Bryce Stewart • Kevin Stokesbury • Samantha Stott • Claire Szostek • Oliver Tully • Fabian Zimmermann

International Council for the Exploration of the Sea
Conseil International pour l'Exploration de la Mer

Contents

i Executive summary

The ICES Scallop Assessment working group (WGScallop) discusses the key issues surrounding scallop species and is working towards the development and improvement of appropriate stock assessment methods. The WG shares expertise on survey methodologies, advances in technology and recent studies on scallop species.

In this report, the WG summarises data submitted via the 2020 data call, provides an update on the various data requirements for stock assessments; fisheries catch data (landings and effort), surveys, and studies of the biology of the various scallop species. The WG intends to have an annual data call and will provide detailed feedback to the Secretariat on issues to be resolved prior to the next data call. Progress with annual scientific and industry led surveys were reviewed across the ICES areas and the various data requirements for stock assessments were discussed in detail by the group.

Exploratory analyses using surplus production models (with and without effort) were run for king scallop in the north Irish Sea. Work towards a full stock synthesis assessment will continue to be progressed for next year. A number of institutes collect data on queen scallops during either species specific surveys or as bycatch in surveys targeted at other species (king scallops and demersal gadoids). An intersessional subgroup was established to facilitate advances on queen scallop stock assessments and an update will be provided at the next WGScallop meeting.

The global Covid-19 pandemic has caused significant disruptions to scallops surveys. Staff exchange on surveys planned for 2020 were not possible due to restrictions or cancellations but will be attempted again in 2021. The WG agreed that a second Workshop on Scallop Aging (WKSA2) will take place in 2021.

ii Expert group information

Expert group name	Scallop Assessment Working Group (WGScallop)
Expert group cycle	Multiannual
Year cycle started	2019
Reporting year in cycle	2/3
Chair(s)	Lynda Blackadder, Scotland, UK
Meeting venue(s) and dates	5–9 October 2020, online meeting (27 participants)
	8–11 October 2019, Douglas, Isle of Man (22 participants)

1 Update on workplan

The WGScallop resolution covers a three-year workplan period. Every year the WG reviews and reports on current scallop work and shares expertise, knowledge and any technical advances. The WG keeps current biological parameters under review and will update these when information becomes available.

The first year aimed to draft and issue a data call for landings and effort data, collate a list of data available for the Irish Sea, draft a resolution for an age reading workshop, arrange scientific staff exchange on surveys and exchange knowledge on current scallop stock assessment methods.

The second year aimed to collate the available data for the Irish Sea, hold an age reading workshop, update and report and larval dispersal models and attempt to collaborate on further work, and further review scallop stock assessments carried out by national institutes.

The third year aims to conduct a stock assessment for the Irish Sea, issue scallop age reading guidelines, produce maps on genetic stock structure and larval dispersal, and further develop scallop stock assessment methods.

2 Progress report on ToR

This interim report presents a summary of presentations or discussions ordered primarily by terms of reference (ToR).

2.1 ToR a) Compile and present data on scallop fisheries in ICES sub areas 2, 4, 5, 6 and 7 by collating available fishery statistics

Last year the WG had access to limited scallop landings and effort data through the ICES Regional Database (RDB). A sub group evaluated the data and noted data missing from countries with known scallop fisheries and there appeared to be inconsistencies in the landings when compared to in-house data sources. The WG agreed a data call was required and ICES issued this in August 2020; requesting landings and effort data for scallop species in ICES areas 2, 4, 5, 6, 7, 8 for the years 2000–2019. A copy of the data call is available on the ICES website at this link: datacall.2020.WGSCALLOP_data

Nine countries provided data in some capacity. Data were checked and ICES rectangles, species codes and metiers were standardised between countries. A number of issues were highlighted and these are summarised below (Table 1). These were discussed and where possible rectified within the meeting by the WG member contacting their national data submitter. It should be noted that at this stage the data reported this year are still preliminary. A number of members highlighted that there are often differences between in-house data sources and those in the national databases. Differences could in part be explained by a lag time between fisher's log book data being entered/uploaded to the national database or because of the way the data were aggregated.

Country	Issue	Rectified	Next steps
Channel Islands	No data included/submitted.	Contact made with scientists from Channel Islands. Invitation to join WG.	Check if data available through iFISH or make request through data call next year. Establish regular contact with Channel Island scientists.
France	No species codes. Many entries have no ICES rectangle provided.	Data resubmitted with species codes.	
Ireland	No data for <10 m vessels 2000–2014.	These vessels constitute a very small proportion of the fleet.	
Isle of Man	No data prior to 2011.		Make specific request through data call next year.
Norway	No statistical rectangles. Total annual landings. Effort is number of vessels.	Discussed with Norwegian scientists who will try to resolve issues. Not included in reporting this year.	Problems reported with links in the data call. To be raised with ICES.
Scotland	No data prior to 2002.		

Table 1. Issues identified with the 2020 WGScallop data call and steps taken to rectify them.

The metier (level 5) codes also caused some problems and it was suggested that the scallop dive sector did not appear to be appropriately represented in the data. This is important for those countries with significant dive caught landings (Scotland and Norway) and there are concerns that these landings are being attributed to metier codes for pots and creels or miscellaneous. We will aim to rectify this in the next data call.

The definition of all the fishing trips of the French fleet with their associated features (dates, fishing area, metier, gear and mesh size, total weight and value of landings by species) is based on a cross-validation tool: SACROIS (http://sih.ifremer.fr/Description-des-donnees/Les-donnees-estimees/SACROIS) of the different available data (fleet register, annual fishing activity calendars, logbooks, monthly declarative forms, sales note data, geolocalisation data) aiming to provide the best possible fishing statistics data.

SACROIS cross-checks data from different declarative sources, as required in article 145 of the EU control Regulation (EC Reg. 404/2011). The application crosses information, at the most disaggregated level, from the fishing fleet register, logbooks, monthly declarative forms, sales notes data, geolocalisation data and the scientific census of annual fishing activity calendars, in order to build a dataset compiling the most accurate and complete information for each individual fishing trip. The application verifies and controls the different sources of data, with the aim of displaying validated and qualified landings per species and effort data series. The application also provides several quality indicators and evaluates the completeness of the data flows. A specific algorithm is included into SACROIS to estimate the value of landings based on sales note data available (sometimes directly deducted from them) or estimation of an average price. SACROIS also includes the allocation of a single metier to a fishing trip, based on the dominant landed species (or group of species) by value (by a raw ordination), the vessel' activity calendar survey and eventually the declared gear (see detailed methodology explained in 'Anonymous, DCF metier workshop report, 2018').

A separate issue identified was the calculation of fishing effort (kw days). This was discussed at UK level at the time of submission regarding whether effort should be represented as ‘days at sea’ multiplied by engine power, or ‘days of active fishing’ multiplied by engine power. England, Wales and Norther Ireland submitted the data using ‘days of active fishing’ whereas Scotland used ‘days at sea’. The WG doubt that this will make any considerable difference to the overall estimates as the measures are probably very similar (especially for short trips) however we should ensure this is clarified in the data call for next year.

In terms of addressing the ToR to collate and present available fisheries data, the WG was pleased at the progress made and discussed the need for standardising this process in terms of the data checking, storage and how the data are presented. The WG will continue to refine this process and seek advice from ICES. Three scallop species codes were listed in the data received (QSC; queen scallop, SCE; king scallop SCX; scallop species unidentified) with king scallop landings dominant. Collation of preliminary king scallop landings show the majority are from ICES subarea 7 (Table 2). Total landings have increased steadily over the period from 2000 to 2012 with a peak in the time-series of approximately 64 000 t landed for the sub areas reported (Figure 1). Landings fell slightly but have been increasing again and were reported as approximately 61 500 t in 2019.

	ICES sub area						
Year	2	4	5	6	7	8	Total
2000	0	147.9	0	122.5	23964.1	783.2	25017.7
2001	0	814.8	0	79.5	26965.4	1048.5	28908.2
2002	0	3174.9	0	6651.1	32104.6	788.7	42719.3
2003	0	4221.9	0.4	5968	32866.9	973.3	44030.5
2004	0	5674.5	0	5145.5	40618.7	902.9	52341.6
2005	0	4916.3	0	4409.7	44211.5	1038.4	54575.9
2006	0	4889.9	0	3392.7	41688.6	1189.3	51160.5
2007	0	5458.2	0	3028.3	42820.7	1340.6	52647.8
2008	0	4805.4	0	3909.4	45827.5	1288.7	55831
2009	0.2	5361.4	0	3545.7	44967.3	906.1	54780.7
2010	0	4829.2	0	3438.8	51325	479.4	60072.4
2011	0	3800.8	0	3503	53244.2	260.7	60808.7
2012	0	5532.2	0	5311.5	52224.4	874.6	63942.7
2013	0	7596.5	0	4536.7	49799.2	826.7	62759.1
2014	0	7072.5	0	5306.7	41439.6	348.2	54167
2015	0	9027.8	0	4357.1	39778.2	496.6	53659.7
2016	0	7706.9	1.6	4737.4	43765.7	677.2	56888.8
2017	0	7667.5	0	3569.3	46090.3	716.2	58043.3
2018	0.1	6242.6	0	2936.4	50797.2	718	60694.3
2019	0.8	5635.1	0	2901.6	52391.8	617.1	61546.4

Table 2. Provisional landings (live weight (including shell), t) of king scallops for 2000–2019 by ICES subarea as submitted through the ICES data call. Data for the Isle of Man is not available prior to 2011 and data for Scotland are not available prior to 2002.

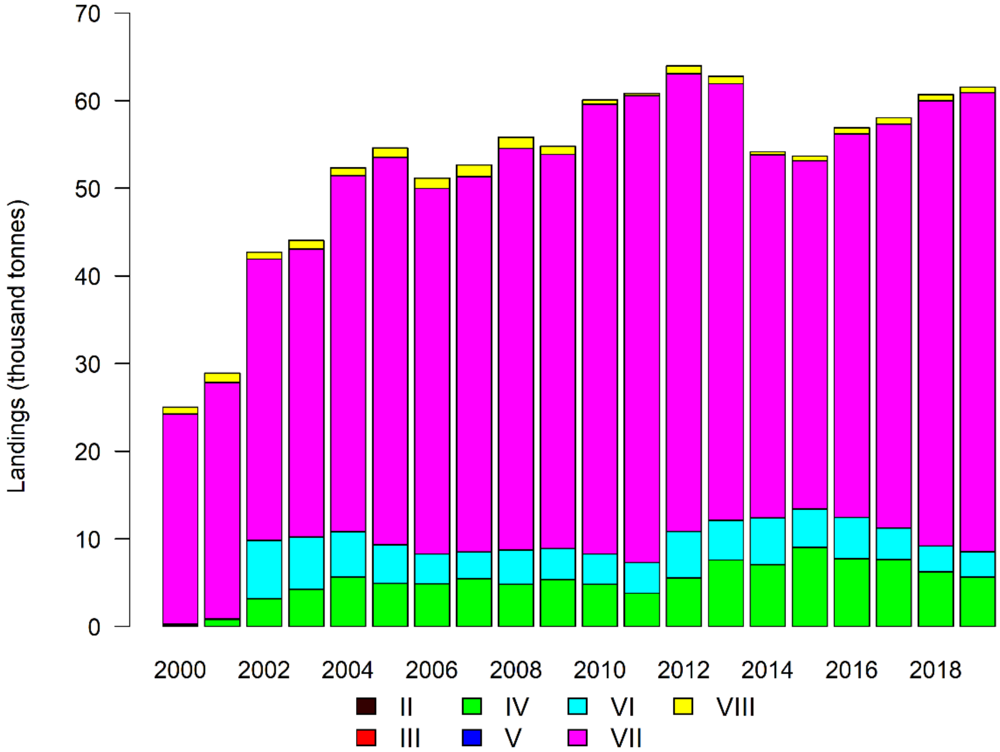

Figure 1. Annual landings (live weight, thousand t) of king scallops each year. Landings are divided by ICES Subarea within each year as coloured by the legend. Data for Isle of Man are not included prior to 2011 and Scotland are not included prior to 2002.

The landings and data collated from the data call are described below for the Irish Sea and for preliminary work on queen scallops. Data will be stored on the SharePoint and only used for the purposes intended by this WG to progress scallop stock assessments.

Marine Institute – Ireland. King scallop (*Pecten maximus*) fishery update

Total landings from the Irish king scallop (*Pecten maximus*) fleet have remained relatively stable since 2011, generally varying between 2000 and 2500 t per annum, with the exception of 2013 when landings peaked at close to 2800 t. In 2019, scallop landings totaled a reported 2332 t, marginally higher than the 2284 t reported in 2018.

The Irish fleet's traditional fishing grounds are in the Celtic Sea, but the fleet is nomadic, with the Irish Sea and the English Channel also of importance to the fleet (Figure 2). The Irish Sea, Cardigan Bay and the north-east Irish Sea (south of the Isle of Man) are areas that are regularly fished. In more recent years, the eastern Channel area has been of increasing importance to the fleet, and after the Celtic Sea is the area that provides the most landings (Figure 3). This increase in effort and landings from the eastern Channel area in recent years appears to have replaced effort and landings from the Irish Sea areas in previous years. Combined landings of just over 200 t were reported from Cardigan Bay and the north-east Irish Sea in 2019, compared to almost 1000 t in 2011 (Figure 3). In 2019, the vast majority of landings by the fleet came from the Celtic Sea and the eastern Channel area, with 1260 and 790 t reported, respectively.

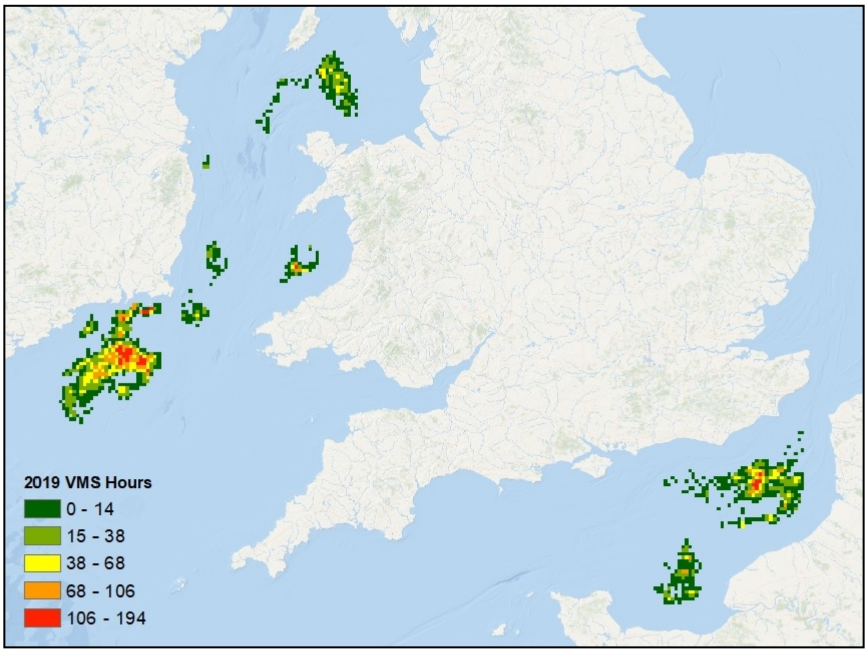

Figure 2. Distribution of fishing effort by the Irish scallop fleet in 2019.

Catch rates, or catch-per-unit-effort (i.e. kg per dredge per VMS fishing hour) indicate that since 2015, the eastern English Channel is the most productive area fished by the Irish fleet (Figure 4). However, from 2015–2018, catch rates in the eastern Channel were stable at around 8, but dropped substantially in 2019 to 4.6 kg per dredge per VMS fishing hour. In 2019, effort by the fleet increased substantially in the eastern Channel compared to 2018, but similar levels of landings were reported, resulting in a reduced catch rate. In the Celtic Sea, Cardigan Bay and north-east Irish Sea catch rates have followed similar trends since 2011, with an overall slight decline in catch rates observed throughout the time-series (Figure 4). In areas such as the south and west Irish Sea, and western English Channel catch rates are more variable, but this is likely due to the low and sporadic levels of landings from these areas.

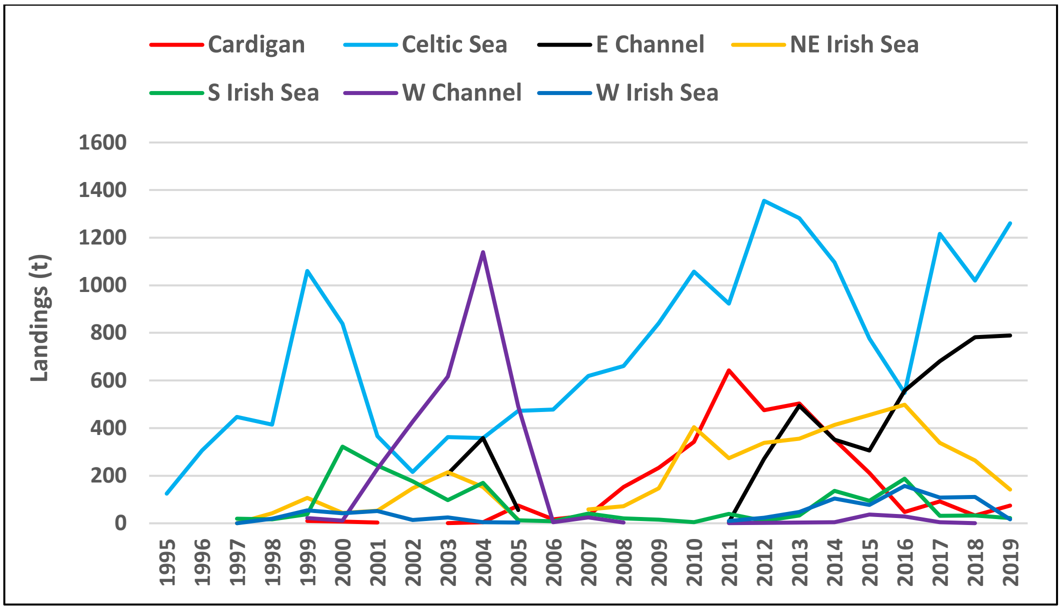

Figure 3. King scallop landings from the main areas fished by the Irish fleet 1995–2019.

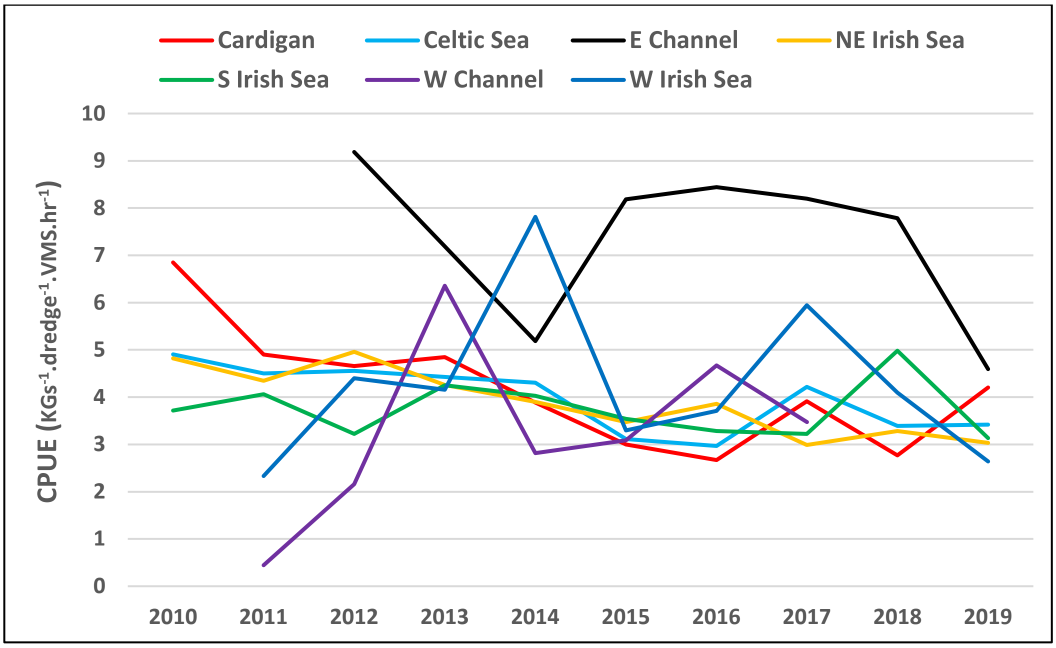

Figure 4. King scallop catch rates from the main areas fished by the Irish fleet 2010–2019.

2.2 ToR b) Review recent/current stock assessment methods of the main scallop species and explore other methodologies; including comparisons with fishery dependant indicators

Norway is currently evaluating a reopening of the Iceland scallop (*Chlamys islandica*) fishery in the Svalbard area, and IMR was tasked to assess the stock status and provide advice on a potential fishery. Due to the lack of recent commercial catches and fisheries-independent time-series, two surveys were conducted in 2019 and 2020 to determine stock density and composition. Under Water TV (UWTV) mounted on a video rig floating above the sea floor (2019) and on a video sledge (2020) was used to count scallops on video transects while dredge stations were conducted to collect biological samples and determine the age structure and age-size relationship. The obtained data was used to estimate stock biomass on three scallop beds that were major fishing grounds in the past, and combined with life-history data from the literature in an MSE simulation approach to estimate sustainable fishing mortality and catch, and explore the uncertainty around reference points.

Natural mortality and recruitment are the most important unknowns in a data-poor situation such as for Iceland scallops in Norwegian waters. The potentially wide range of the underlying parameters was therefore explored in stochastic simulations with probabilistic assumption on natural mortality and recruitment. Natural mortality was modelled as a gamma distribution based on empiric estimates of natural mortality in Iceland scallop stocks in the literature. A value of natural mortality was randomly drawn from the resulting distribution in each simulation and held constant over time. The specific value of natural mortality was also used to back-calculate recruitment in every simulation from the abundance-at-age estimates obtained during the surveys. From the specific time-series of back-calculated recruitment, means and standard deviations were calculated to inform a log-normal distribution of recruitment from which annual recruitment values were randomly drawn. To introduce density-dependency, a double hockeystick-type relationship between recruitment and spawning stock was used based on the assumption that: 1) recruitment decreases linearly for stock sizes above the current unfished stock biomass due to increasing competition for space and resources; and 2) recruitment decreases linearly below limit biomass which leads to impaired recruitment. Because empiric information on stock-recruitment relationships is lacking for Iceland scallops, the limit biomass was modelled as a normally distributed value with a mean at 33% of the unfished biomass and a standard deviation of +/- 10%. Subsequently, the limit biomass was selected randomly in each simulation. This approach allows to simulate stock trajectories under renewed fishing and determine reference point across a wide range of assumptions on natural mortality and recruitment.

The results suggest that F_{MSY} across all simulations lies at 0.25, while a more precautionary fishing mortality would need to be set at 0.19. This would result in approximately 16 000 t and 15 000 t of catches (round weight), respectively. For both fishing mortalities, a low risk (<5%) of falling below B_{lim} was estimated. However, the results show a strong dependency on the specific assumption on natural mortality and recruitment. F_{MSY} more than doubles (from below 0.2 to above 0.4) with B_{lim} decreasing from 50% to 20% of unfished biomass, as a low B_{lim} implies a more productive and resilient stock (Figure 5). Natural mortality indicates an exactly opposite relationship with an F_{MSY} that decreases to less than half (from over 0.4 to under 0.2) from a natural mortality at 0.18 to 0.02. In addition, all results depend on the assumption of a perfect knife-edge selectivity at the minimum landing size (65mm shell height), which corresponds to the average size at maturity. This builds on the development of a new gear type using suction technology that was shown in experimental trials to be much more selective and less damaging to benthos and sea floor than traditional dredging.

The assessment and report highlighted how sensitive the reference point estimates are to these key population dynamics parameters, and therefore that the management advice comes with high uncertainty. A precautionary approach and continued monitoring were therefore advised to the Norwegian authorities if the fishery is reopened.

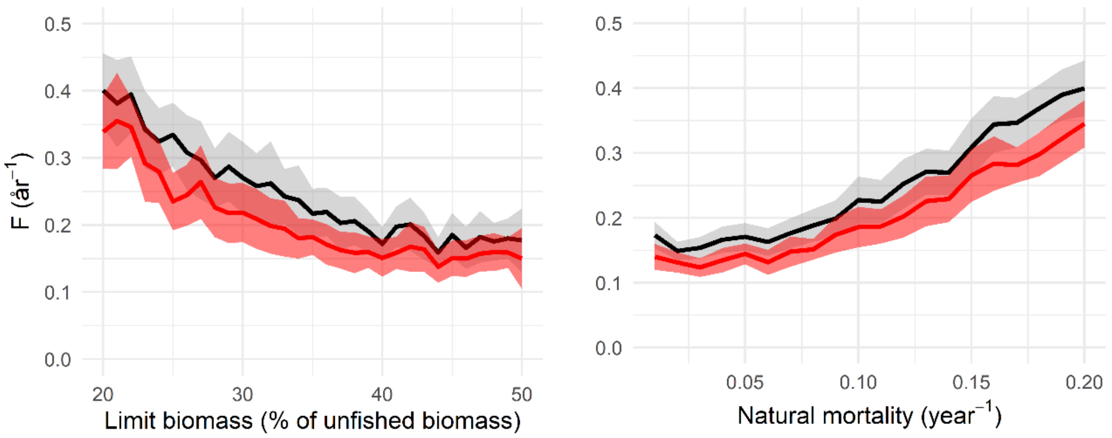

Figure 5. F_{MSY} (black) and a more precautionary F_{PGY} (red) in relation to a range of limit biomass (left) and natural mortality (right) values. Shaded areas show 95% confidence intervals.

Work on the Irish Sea stock assessment(s) is considered under ToR c below.

2.3 ToR c) Collate all available data and attempt to conduct a stock assessment for the north Irish Sea

The Isle of Man currently conducts stock assessment for king and queen scallops within their territorial sea and this WG intends to try and assess the wider Irish Sea area. The ToR cover a 3 year period (2019–2021) and the expected deliverable is a stock assessment for the north Irish Sea (Figure 6). It is currently not known whether king scallops in this area consist of a single or multiple stocks and work continues to improve our knowledge using genetics, larval dispersal and connectivity (see details under other ToR for this WG). This stat rectangles shown in Figure 6 were selected by the WG as a test case for stock assessment because they encompassed all of the main scallop fishing areas in ICES Division 7a and WG members agreed to share national data for this species. Work will continue to determine the most appropriate scale of assessment and will consider a range of spatial approaches, including a single area assessment, spatially structured assessments and fully separated sub-area assessments. The WG are keen to make clear that its purpose is to progress stock assessments for scallop species and decisions on level of aggregation of stock assessments will be based on stock identification science, available data (biological parameters, fishery and survey data) and assessment model performance; and not on the management of these fisheries.

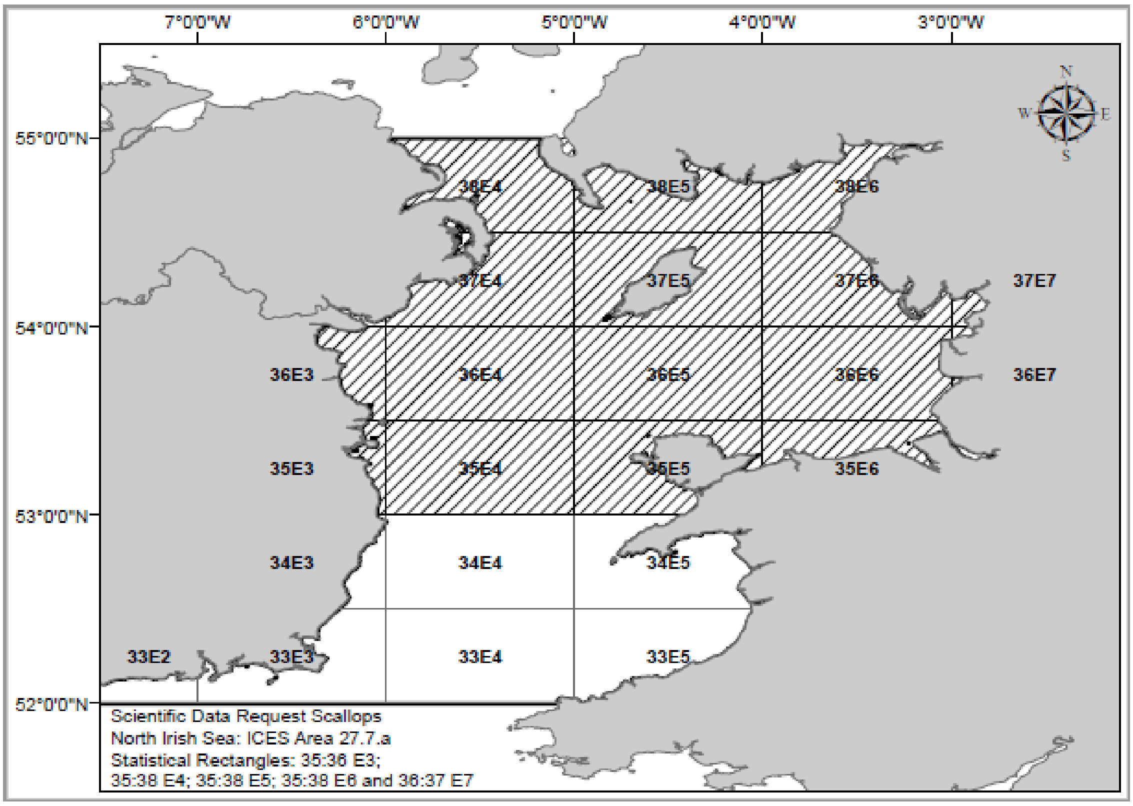

Figure 6. Irish Sea ICES rectangles identified by WGScallop to progress ToR c.

During Year 1, the WG agreed which area to assess and established which scientific institutes held relevant data. Meta data were collated in Year 1 and significant progress was again made in Year 2 with the subgroup developing universal templates for each institute to supply the available data in the required format. Two templates were prepared, the first of which was a basic template which provided simplified data to enable surplus production models to be applied. The second template required more detailed data on age and length to allow a wider range of models to be trialled. The data have been collated to run initial exploratory assessments for each using a simple surplus production model (input data includes survey biomass, swept area and commercial landings and discard data), and a more complex surplus production (which in addition requires a time-series of effort data – kW days).

During initial discussions about the exploratory assessments, a range of challenges were highlighted requiring further exploration prior to a final assessment being agreed. These include the treatment of closed areas within the assessment, the quantification of fishable area within each ICES Rectangle (which is the level at which commercial landings are reported), the stock assessment methods to trial and the standardisation of survey and commercial indices.

The WG agreed to provide polygons indicating the extent of king scallop fishing based on long term time-series (i.e. 2009 to 2019) of VMS data to enable the fishing areas of national fleets to be mapped and quantified across the Irish Sea. Preliminary maps are presented below (Figure 7 and 8) and will be verified with any additional available information next year. Data templates will be reviewed and then distributed to data suppliers within the WG.

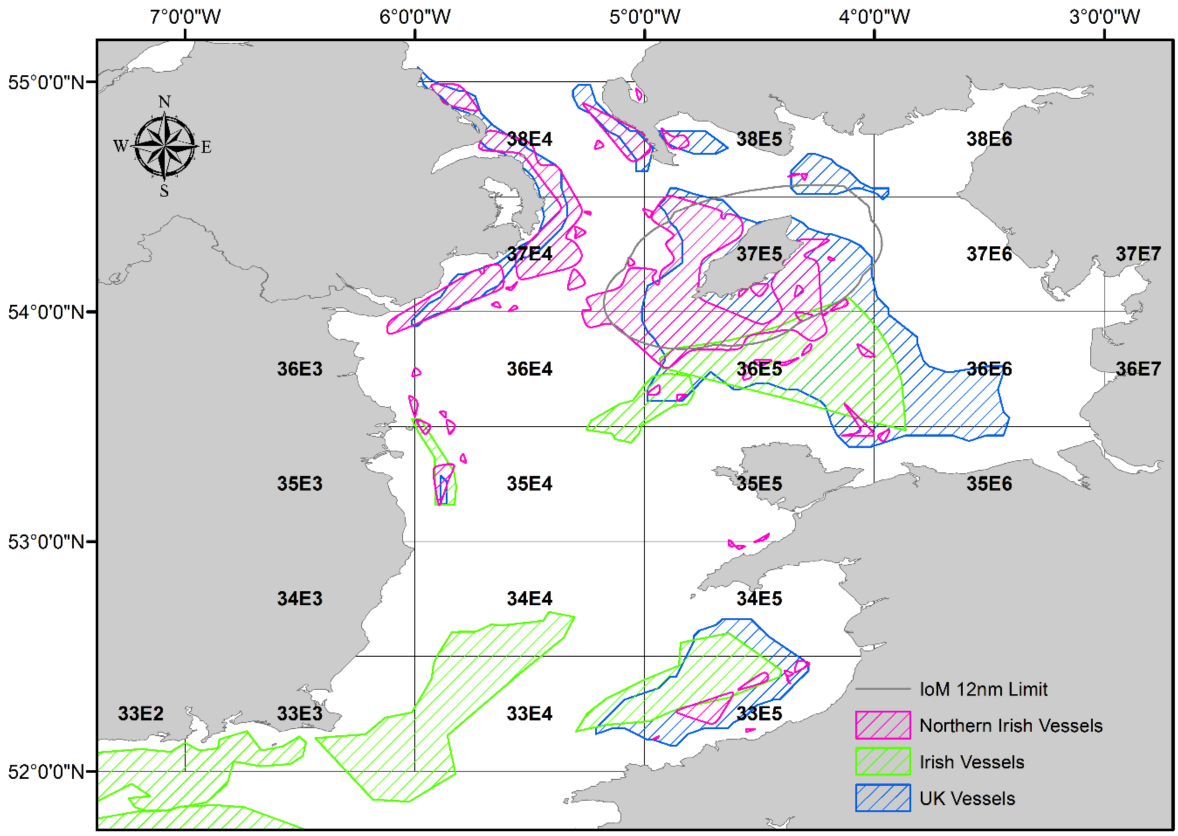

Figure 7. VMS Polygons showing the outer extent of historical king scallop fishing activity with individual jurisdiction polygons (dates and sources described below).

The maps display the extent of king scallop fishing activity (i.e. polygons drawn around the extend of filtered and cleaned VMS data) using data from vessel monitoring system (VMS), which is a satellite-based fishing vessel monitoring system providing data at regular intervals on the location, course and speed of vessels. The system is compulsory for:

- EU vessels above 15 m
- EU vessels above 12 m from 1 January 2012
- Any vessel fishing for scallops within the Isle of Man territorial sea

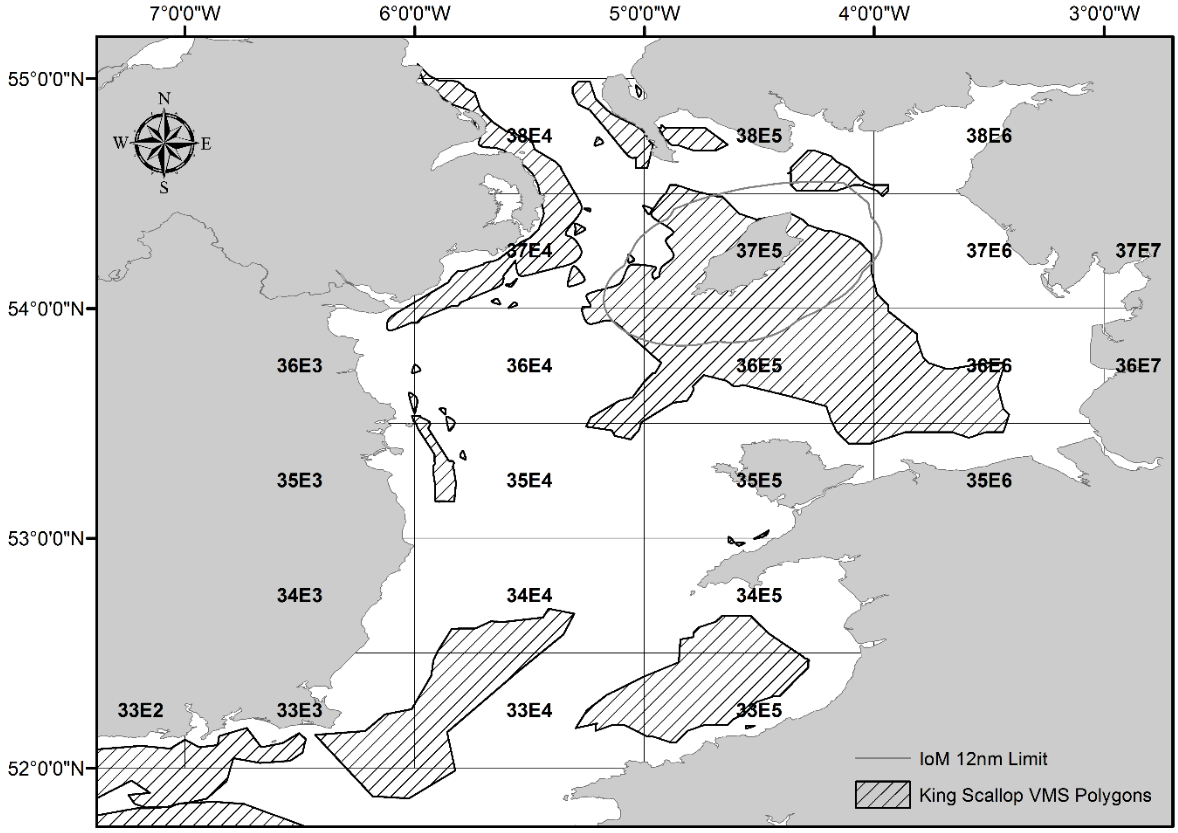

Figure 8. VMS Polygons showing the outer extent of historical king scallop fishing activity with combined polygons covering all jurisdictions (dates and sources described below).

The VMS polygons presented here represent the extent of the fishery exploited by the vessels providing VMS data over this time period. The VMS polygons will include the use of VMS points where fishers no longer fish or are exploring beyond traditional grounds. We anticipate that towards the periphery of the polygons there may only be limited fishing intensity. In addition, some of the defined polygons may have areas within them that have no or low VMS data (holes) which are not shown.

Data sources:

- VMS data polygons from Cefas including vessels from England, Wales, Scotland, Isle of Man, Guernsey and Jersey fishing for king scallops from 2009 to 2017 filtered to fishing speed of 1 to 5 knots.
- VMS data polygons from AFBI for Northern Irish Vessels fishing for king scallops from 2012 to 2016 filtered to fishing speed of 0.5 to 4 knots.
- VMS data polygons from the Marine Institute for Irish Vessels fishing for king scallops from 2012 to 2019 filtered to fishing speed of 0.8 to 5 knots.

The WG agreed that all data relevant to the North Irish Sea stock assessment should be stored on SharePoint for access by WG members to trial different assessment methods. Code can also be stored on SharePoint initially but with a view to move to Github to improve version control. Once all the data are collated then it will need to undergo initial analysis, exploration and documentation to identify differences among and between survey methods and population life-history metrics (i.e. growth rates and age composition). A two-pronged approach will be taken by the subgroup over the final 12 months of the ToR looking at applying a surplus production model in the short term, and in the longer term, developing assessments which incorporate age and length data. The subgroup will convene regularly over the next 12 months to ensure progress towards the expected deliverable of a preliminary stock assessment for the North Irish Sea for Year 3.

As mentioned under ToR a), the WG collated the landings data and spent time discussing the Irish Sea. There are issues (already noted under ToR a) but the preliminary data confirm that a number of countries fish for scallops in this region (Table 3) and that the total landings for king scallops in the Irish Sea have been declining since 2011 (Figure 9).

Year	Belgium	England and Wales	France	Ireland	Isle of Man	Netherlands	Northern Ireland	Scotland
2000	0	1055	0	523.3	NA	0	448.5	NA
2001	0	954.9	0	445.4	NA	0	557	NA
2002	0	768.3	0	376.4	NA	2	368.4	637.2
2003	0	799.8	0.5	443.7	NA	0	452	635.1
2004	0	831.6	0.4	515.4	NA	0	480.7	982.2
2005	0	882.2	0	307.1	NA	0	352.7	840.1
2006	8.6	957	0	403.3	NA	0	273.9	732.1
2007	6.1	2162.3	0	492.4	NA	13.3	360.2	958.6
2008	90.4	4495.3	0	519.3	NA	277.9	523.5	1316.3
2009	8.6	3833.6	0	538.1	NA	17.3	589.3	1676.2
2010	133.5	3197.9	0	888.3	NA	0	771	1585.1
2011	223.4	3086.9	0	1321.8	1589.8	0	847.7	1259.7
2012	40.8	4221.3	0	1374.3	1939.6	0	999.5	1040.4
2013	1.1	2768.4	0	1552.4	1960.7	0	981.5	1109.9
2014	1.4	1790.6	0	1677.9	2496.1	0	1009.3	1137.4
2015	1	1339.9	0	1085	2406.5	0	1161.4	870.5
2016	0.4	1358.4	0	1037.7	3232.7	0	1228	1368.9
2017	0.8	763.8	0	720.6	2217	0	960.6	894
2018	0.8	1129.1	0	559	2019.3	0	744.1	916.7
2019	4	1019	0	467	1629.9	0	554.7	579

Table 3. Provisional total landings (live weight, t) of king scallops by nation and year in ICES Division VIIa (Irish Sea) 2000–2019. Note Isle of Man landings prior to 2011 and Scotland landings prior to 2002 are not available.

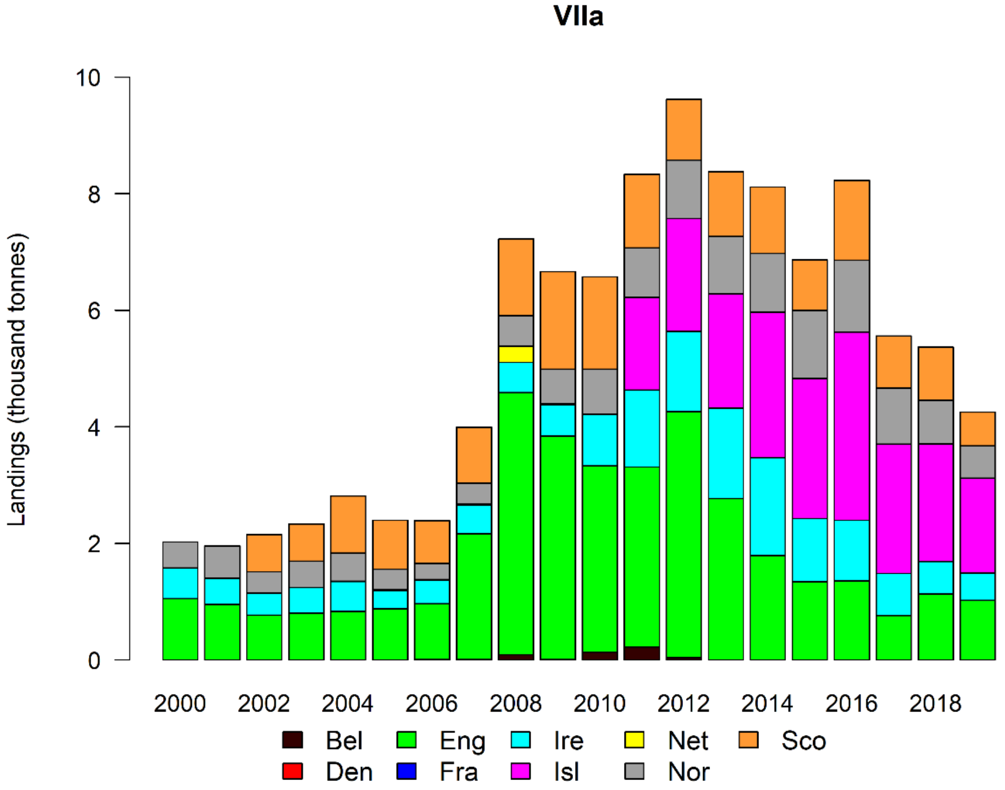

Figure 9. Provisional annual landings (live weight, thousand t) of king scallops from ICES sub area VIIa (Irish Sea) 2000–2019. Landings by nation are colour coded. Bel -s Belgium, Den -Denmark, Eng is England and Wales, Fra is France, Ire is Republic of Ireland, Isl is the Isle of Man, Net is the Netherlands, Nor is Northern Ireland and Sco is Scotland. Note Isle of Man landings prior to 2011 and Scotland landings prior to 2002 are not available.

2.4 ToR d) Review and report on current scallop surveys and share expertise, knowledge and technical advances

Scallop surveys continue to be an important data source for the stock assessment in many areas and it is acknowledged that a break in the survey time-series (years with no data) is not ideal, and in some situations may make the provision of management advice particularly difficult. The Covid-19 global pandemic has caused significant disruption for most institutes and their annual scallop surveys. A number of institutes were able to complete surveys in certain assessment areas. A summary of surveys planned, executed, or disrupted is provided in Table 4.

Country	Target species	Typical/planned surveys	Covid-19 disruption	Other issues (weather/funding/ship/staff)
France	King scallop	Annual survey, Bay of Saint-Brieuc (VIIe,26e7)	No Covid disruption	Funding since 2017 (partnership scientists/fishing industry). Same vessel > 30 years.
Wales	King and queen scallop	Annual survey	Delayed from April until August	Two of seven sampling days lost to weather
France	King scallop	Annual survey, Bay of Seine (7d,27E9 and 28E9)	No disruption, but effect on sampling design	Change of vessel this year (Fishing vessel), less sampling points, only French territorial waters. Delayed two months (September instead of July). Fund by EU since 2017, partnership between scientists, fishers.
England	King scallop	Annual dredge survey Western English Channel and Celtic Sea (selected areas)	Delayed from May to August	Survey positions inside French EEZ not carried out
England	King scallop	Annual drege survey Eastern English Channel and North Sea (selected areas)	Completed to schedule	Survey positions inside French EEZ not carried out
England	King scallop	UWTV survey in selected unexploited areas	Cancelled	*Adhoc* survey not carried out annually but was due this year
Scotland	King scallop	Annual dredge survey - Shetland (15 days)	No Covid disruption	Four days lost to weather, but still successful
Scotland	King scallop	Gear comparison survey (7 days)	No Covid disruption	Six days lost to weather (one day fishing)
Scotland	King scallop	Annual dredge survey - West coast of Scotland (21 days)	Cancelled	
Scotland	King scallop	Annual dredge survey - East coast of Scotland (20 days)	Cancelled	
Scotland	King scallop	Dredge survey - Clyde (14 days)	Cancelled	
Northern Ireland	King scallop	Annual dredge survey	No Covid disruption	
Northern Ireland	Queen scallop	Annual UWTV and fishing survey (June/July)	Cancelled	
Isle of Man	King and queen scallop	Annual scientific survey	Delayed from April to September and then cancelled du	Bangor University contract extended for 5 years so survey guaranteed until 2025
Isle of Man	King and queen scallop	Annual Industry survey	Went ahead adhering to CV regulations	Short term data set (2 years) so not available for stock assessment; no funding process in place as yet for ongoing surveys

Table 4. A summary of scallop surveys and any issues or disruptions in 2020.

The WG had previously agreed that scientific staff exchange is useful and plans were underway for a number of national experts to work on each other's surveys in 2020. This was all curtailed because of the Covid-19 disruption. WG members agreed that this would still be useful, to share expertise and to allow other institutes to view different technologies or techniques, and will try and arrange staff exchanges in 2021 if possible.

Some countries noted that lack of secure funding for surveys and advised the WG that some surveys are likely to be discontinued. In Norway, there are currently no routine surveys and future surveys will depend on available funding for specific monitoring and research project. Other institutes highlighted that it is not the lack of funding that is the issue but instead the process of having to prioritise work. It was highlighted that for many countries the lack of advice requests for scallop species means that these species were given less attention than we would like.

The WG also discussed the various ways that the fishing industry can contribute to data collection; especially because of the difficulties and expense of research vessel surveys.

In France, the fishers are represented by Fishermen committees, from local to national level. Each French administrative department along the coast line, as "Calvados", or "Manche" or "Côtes d'Armor" for example, has a local "Comité Départemental des Pêches Maritimes", led by elected fishermen. At the regional level, each administrative region (Brittany, Normandy and High of France from west to East, has also a "Comité Régional des Pêches Martimes", and a national committee in Paris for all France ("Comité National des Pêches Maritimes"). Each structure employs permanent staff, who typically have either a scientific or legal education. It is therefore relatively simple to establish links between science and industry to conduct shared projects. For the king scallop fisheries in France, moreover the links between science and industry are strong and old, especially in the two main fisheries of the Bay of Seine in Normandy and the Bay of Saint-Brieuc in Brittany, because in these two areas there is a long tradition (more than 40 years) of assessment surveys leaded by Ifremer, and shared with the industry. For example, the COVID-19 situation in 2020 led to the cancellation of the Bay of Seine survey which is usually undertaken by the French R/V Thalia. This survey has been replaced in a couple of days by a reduced survey on a fishing vessel, only within the French territorial waters but with the same scientific protocol, allowing to maintain the continuity of the historical time-series.

The Isle of Man also have experience of industry surveys. A summary of the presentation is provided below;

Isle of Man. Industry Surveys. King and queen scallop (*Pecten maximus* and *Aequipecten opercularis*)

The Isle of Man has a long term time-series of survey data from annual scientific surveys of scallops within the territorial waters (1992–2019). This survey has a coarse resolution of fixed survey stations (~ 3 nautical miles) and uses a single dredge bar of 2 x standard king scallop dredges and 2 x standard queen scallop dredges. A short-term fine-scale industry survey has also been run in parallel to the annual scientific survey for the last two years (2019–2020). This survey is randomised stratified in design and uses two dredge bars, one the same as the scientific survey and the other modified to look at juvenile scallops (2 x standard king scallop dredges and 2 x modified queen scallop dredges with additional teeth and smaller mesh size). The fine-scale survey enables better identification of localised hotspots and a recruitment index for queen scallops (standard queen scallop dredges provide an index of king scallop recruitment in both surveys). For the 2019 and 2020 queen scallop fishing seasons the Isle of Man have moved towards spatial management of the fishery at the level of fishing ground using soft landings thresholds and soft LPUE thresholds (i.e. additional harvest control rules are discussed once soft LPUE or landings thresholds are reached at a fishing ground). There are pros and cons associated with the use of scientific (i.e. Research Vessel) and industry (i.e. Fishing Vessel) surveys including differences in available working area and facilities, staff numbers, adverse weather restrictions and feasibility of data collection (Table 5). At present the Isle of Man intends to continue to run both the coarse scale scientific survey (from which quantitative biomass estimates can be produced at the territorial sea level) and find scale industry surveys (from which finer scale spatial management can be based).

	Scientific		Industry	
	Pros	Cons	Pros	Cons
Adverse weather		Survey dates booked > 12 months in advance, bad weather during survey period can result in lost days.	Survey can be arranged at shorter notice and only good weather days utilised, so days not lost to bad weather.	
		Survey schedule guided by weather conditions at the start of the survey (wind direction). Available survey time on different coasts can thus be limited during the pre-ordained survey dates.	More flexibility in terms of surveying in different grounds in different weather conditions (i.e. survey period can be extended until suitable weather)	
Staffing & scientific presence	In addition to crew, the 35m research vessel can hold up to 10 scientists.		Can be completely industry led so no sea going commitment for scientists (up to 14 days). Scientists simply feed into data analysis.	Limited to around 2-3 crew members and 0-2 scientists due to constraints of space, safety and insurance.
	Experienced scallop scientists onboard all surveys enabling technical aspects of data collection such as ageing to be undertaken.			On industry led surveys scientists may be limited or absent onboard, limits data collection for technical aspects such as ageing at sea.
Working space and facilities	Large working deck space, wet lab, dry lab, weighing and dissecting facilities, dredge sorting, bycatch sorting tables.			Small working space on deck, no weighing facilities or bycatch sorting areas.
Time-series	Long time-series (1992-2019) which enables quantitative stock assessment with biomass estimates.			Short time-series (2019–2020) which means quantitative stock assessment with biomass estimates cannot be produced.
Costs	Funding guaranteed for set contracted periods in advance (i.e. current funding 2020 – 2025).			Funded by industry but as yet no set process to fund the survey, which is costly. At present, no ability to commit funding except on a year by year basis.
Coronavirus Restrictions		2020 survey cancelled due to coronavirus restrictions and border closures. Further complicated by the vessel and staff being based in Wales and the survey area within IoM waters.	The industry survey was able to proceed within the IoM coronavirus restrictions with crew able to operate with 2m distancing in place with the vessel and crew both based in the Isle of Man.	

Industry engagement and co-management		Low industry confidence in purely scientific data collection.	High confidence in purely industry survey data collection.	
			Industry feel involved in data collection which aids with engagement in co-management and a better understanding of the data and methods.	
Data collection	Ageing data collected onboard, weight and count data, full bycatch analysis (weight, count and id). Samples frozen and retained for subsequent laboratory analysis.			No ageing or weight data collected onboard and no bycatch analysis.
		Only one dredge bar with four dredges can be deployed (2 x standard king scallop dredges and 2 x standard queen scallop dredges)	A dredge bar deployed off each side of the vessel. One matching the scientific survey and one modified to enable collection of juvenile queen scallop recruitment (includes 2 x modified queen scallop with additional teeth and reduced mesh size).	
Vessel and skipper continuity	Survey vessel is usually retained for a long period. Skipper and crew used to surveying procedures.			Vessel continuity can be low (i.e. high vessel or skipper turnover). Also apathy with standardised scientific surveying can be high.

Table 5. Potential pros and cons of scientific and industry scallop surveys based on initial experience in Isle of Man.

Wales update. King scallop (*Pecten maximus*)

Bangor University conducted the 2020 annual Welsh scallop survey from the RV Prince Madog in early August, after being postponed from April due to the Covid-19 outbreak. The scientific staff were reduced from eight to three scientists in line with University regulations, and as a consequence it was not possible to conduct camera sampling which would typically be done overnight. The survey was therefore restricted to dredge sampling only. Regardless of this, the survey was deemed a success with 41 stations sampled across the Cardigan Bay and Liverpool Bay survey areas. Two sampling days were lost due to weather, which prevented sampling of the third and final survey area north of the Llyn Peninsula. In addition, due to the reduced number of scientific staff, some on-board processing was reduced after a small number of hauls, to avoid having to stop the vessel fishing. Such reductions included measuring and aging only 45 scallops per dredge instead of 90, or no processing of bycatch beyond combined bycatch weight caught. The main survey index (numbers of king scallops caught per 100m^2 swept) was less in Cardigan Bay than in 2019, but was a mixture of greater or less than the equivalent 2019 value for subareas within Cardigan Bay.

Northern Ireland update. King scallop (*Pecten maximus*)

The Agri-Food and Biosciences Institute (AFBI) carried out the annual scallop survey within Northern Ireland waters from the 3–7 February 2020. The survey, which is a random stratified design, aims to collect scallop catch data, biological information, damage information, genetic samples and bycatch details.

During the 2020 survey a total of 36 valid tows were completed. Numbers of scallops caught were lower in 2020 compared with 2019. This was particularly evident within ICES rectangle 39E3. In 2020, 14 of the randomly selected stations were the same stations as those sampled in 2019. Of these stations, 10 showed a decrease in catches (standardised to number of scallops per 100 m^2) from 2019 to 2020, with the remaining four showing an increase in catches (Figure 10).

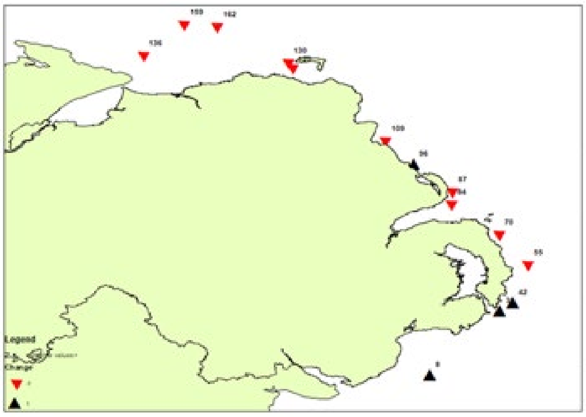

Figure 10. Changes in catches for the fourteen stations samples during the 2019 and 2020 survey (black triangle represents increase, whilst red triangle represents decrease in CPUE).

Overall, the survey CPUE (Figure 11) continued to show a decreasing trend from 2014. The largest decrease was evident in 39E3 which, whilst previously had a much higher CPUE since surveying began in the area in 2011, now has a catch rate equivalent to the Irish Sea.

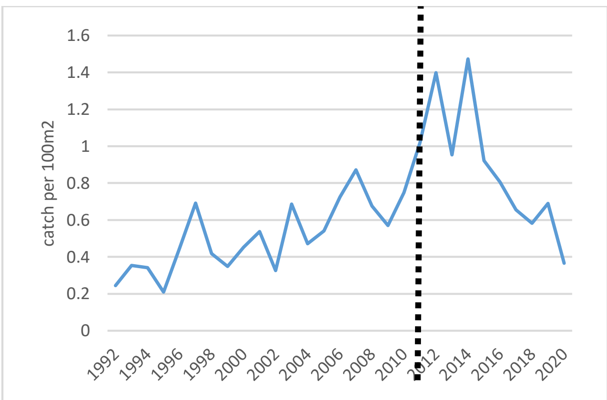

Figure 11. Survey CPUE between 1992 and 2020 (the dashed line indicates the extension of the survey to 39E3 in 2011).

Whilst AFBI also carry out an annual queen scallop survey, in 2020 this was not possible due to COVID-19 restrictions.

Marine Institute – Ireland. South Irish Sea survey 2019

A king scallop (*Pecten maximus*) dredge survey was carried out in the south Irish Sea on board a commercial scallop fishing vessel over five days in September and October 2019. The survey covered areas known locally as the Tuskar and Barrels grounds, off the south-east coast of Ireland, east and south-east of Co. Wexford. This was the first time a dedicated scallop survey has been carried out in this area by the Marine Institute, and was funded and carried out as part of the Ireland-Wales, EU INTERREG BlueFish project.

This dredge survey was carried out using 22 (11-a-side), 30-inch-wide Newhaven spring-loaded dredges. The area to be surveyed was defined using 2014 to 2016 VMS data from the Irish scallop fleet (note: scallop fishing has been negligible in this area in more recent years). In total, sampling took place at 48 random stations across the survey area, with hauls of approximately 1300 meters carried out at each station. All scallop catch and bycatch from each haul was weighed and individually measured. In total, 1129 kg of king scallop was caught and sampled. Queen scallop (*Aequipecten opercularis*) were also caught and sampled at a number of stations in the southern end of the survey area. Sub-samples of king scallop were retained from catches across the survey area and aged using growth marks retained on their shell and hinge. Tissue samples from the adductor muscle of these scallop were also taken and preserved for genetic analysis that is currently ongoing at Aberystwyth University as part of the BlueFish project.

The observed king scallop density across the survey area was 0.0039 individuals per m^2 (4145 scallop/1 074 546 m^2 swept area). This can be compared to the 2019 offshore Celtic Sea survey, carried out onboard the same vessel using the same gear, where observed scallop density was 0.0083 individuals per m^2. The size distribution of scallop from the survey area indicates a predominance of scallop between 100 and 130 mm shell height, with only a minor amount of scallop below this size (Figure 12). The minimum landing size (MLS) for king scallop in this area is 100 mm shell width, equivalent to 89 mm shell height. The drop off in numbers of scallop between MLS and 100 mm shell height may be indicative of a lack of recruitment in this area in recent years, particularly for the northern end of the survey area as the majority of scallop below 100 mm shell height were caught in the southern end of the survey area. Although gear selectivity may be a factor, the same gear effectively caught scallop above the same MLS in the offshore Celtic Sea survey area. It is hoped an ongoing genetics study of scallop populations in the south Irish Sea and Celtic Sea in collaboration with Aberystwyth University will provide information as to whether this population is genetically isolated, or if it relies upon connectivity and larval supply from other areas. Ageing of king scallop indicated that MLS is reached at between 2 and 3 years of age. The oldest age reading for an individual scallop was 25 years.

Relative estimates of biomass for the survey area were produced using geostatistical analysis that utilized an ordinary kriging method (i.e. without co-variables) that takes into account the spatial structure of observed biomass and how density changes relative to the distance between stations using a semi-variogram. This method allows for the interpolation of the survey data across the entire survey area (Figure 13). In the south Irish Sea survey area, the total biomass of scallop, without taking into account the effects of dredge efficiency and selectivity, is estimated to be 1287.7 t. The biomass of scallop above the MLS of 100 mm shell width, equivalent to 89 mm shell height was estimated to be 1277.2 t. It was also estimated that the biomass of large scallop above 120 mm shell width, equivalent to 106 mm shell height, was estimated to be 1062.1 t, or 83% of the stock biomass estimated to be above MLS.

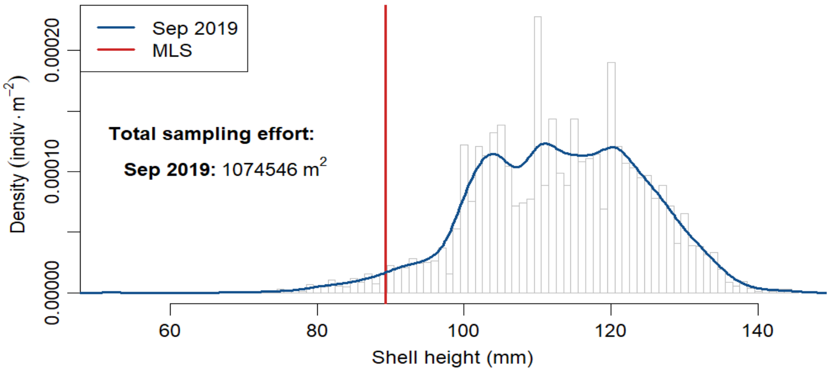

Figure 12. Size distribution and densities of scallop from the 2019 south Irish Sea survey area. Vertical red line at 89 mm corresponds to the MLS of 100 mm shell width.

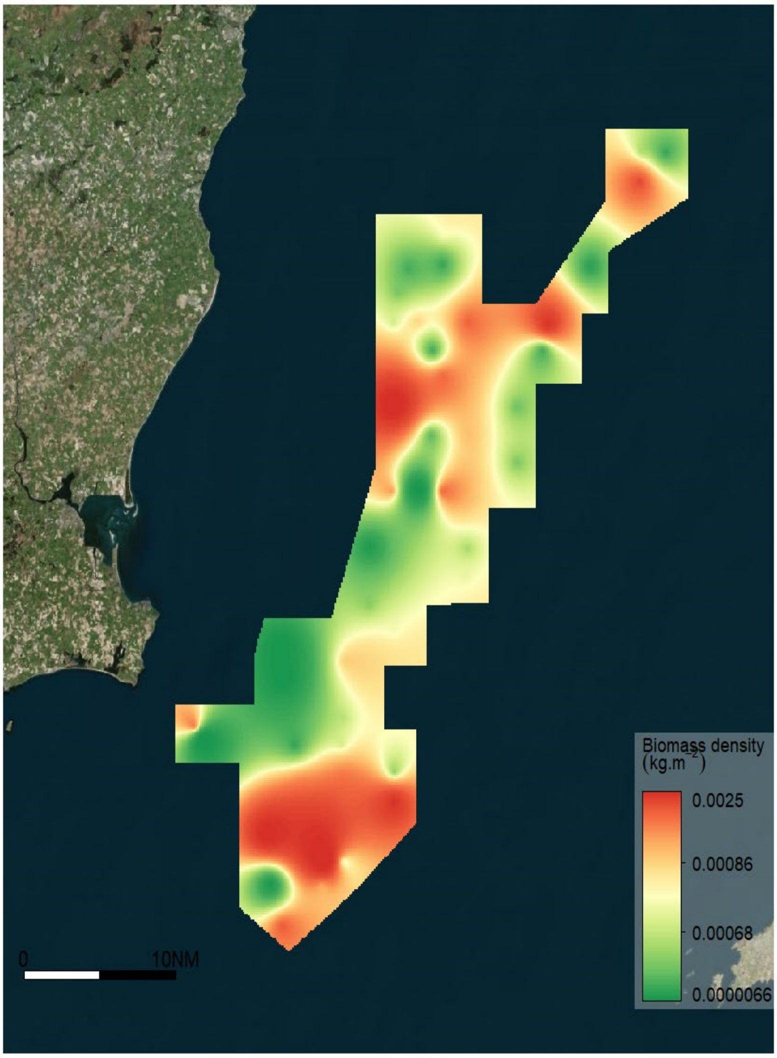

Figure 13. Biomass map for scallop from the 2019 south Irish Sea survey area produced by ordinary kriging.

Updated assessment of 2018 and 2019 Celtic Sea survey data

Results of king scallop dredge surveys carried out in the inshore and offshore Celtic Sea in 2018 and 2019, respectively, were previously presented at the 2019 WGScallop meeting. The areas surveyed were identified from the distribution of VMS data from the Irish scallop fleet. These surveys were carried out on board commercial scallop fishing vessels and were funded and carried out as part of the Ireland-Wales, EU INTERREG BlueFish project.

Classified acoustic backscatter maps that identify substrate types on the seabed had previously indicated that the Celtic Sea scallop grounds consisted predominantly of coarse sediments and sand sediments. However, the substrate of some areas within the Celtic Sea survey area was unknown due to the patchwork nature of the multi-beam acoustic surveys that record backscatter data. Classified backscatter had previously been used as a co-variable to inform the interpolation of both the inshore and offshore Celtic Sea survey data using a geostatistical method known as universal kriging. This method was utilized due to the already established relationship between king scallop density and substrate type in the Celtic Sea; observed densities of scallop are far greater from areas of coarse sediment compared to sand sediment. The 2018 and 2019 surveys confirmed this further, with low, and sometimes zero catches of scallop observed from hauls carried out on areas of sand sediment. Universal kriging allows this observed relationship to be taken into account when interpolating survey data and estimating total stock biomass.

Recently, however, updated classified acoustic backscatter maps have been made available for the Celtic Sea scallop grounds by INFOMAR that carry out multi-beam acoustic surveys in Irish waters. These updated maps of substrate type fill in the areas that hadn't previously been classified within our survey areas, and identifies a large patch of rock in the offshore Celtic Sea area that had previously been classified as coarse sediment. Mapping of VMS data from the Irish fleet for 2012–2019 indicates that this area of rock is actively avoided by the fleet when fishing, with effort focused on the surrounding patches of mixed coarse and sand sediments. At the time of surveying, it had been planned to carry out hauls at stations on this area of rock, in the belief that it was largely an area of coarse sediment at the time, but the presence of static gear in the area prevented this. It is not known if the fleet avoids this area of rock due to the hard substrate possibly causing too much damage to their fishing gear, or because scallop catches are not commercially viable.

The data from the 2018 inshore survey and 2019 offshore survey were combined, and both ordinary and universal kriging models used to re-assess this survey data and produce estimates of biomass for the entire Celtic Sea survey area. With the areas of rock and unclassified substrate removed, the updated classified backscatter map and a bathymetry map that were both at a 100m resolution were used as co-variables. A map of total scallop catches at a 2000m resolution that was produced from 2016–2019 VMS data (i.e. VMS Catch) was also tested as a co-variable. A kriging model that included a zone effect was also tested to account for potential differences in the covariance structure of the spatial survey data from both the inshore and offshore areas.

Ordinary kriging estimated total stock biomass above MLS to be 2590 t (Table 6). In terms of root-mean square error (RMSE), the only model that improved substantially on ordinary kriging was universal kriging with classified backscatter as a co-variable, which reduced the RMSE by 29%. This model estimated biomass to be almost 550 t less than the estimate produced by ordinary kriging (Table 6). As expected, the biomass map produced by universal kriging with classified backscatter as a co-variable indicates that scallop biomass is highest on areas of coarse sediment, and lowest on sand sediment (Figure 14).

Geostatistical Model	Kriging mean (t)	95% CI Low	95% CI High	RMSE	RMSE % (co-var/no co-var)
No co-variable (i.e. ordinary)	2590	2377	2950	0.000619	
Classified backscatter	2041	1837	2150	0.000441	0.71
Bathymetry	2626	1914	3300	0.000611	0.99
VMS Catch	2481	2260	2850	0.000608	0.98
Zone effect	2596	2348	2976	0.000611	0.99

Table 6. Estimates of scallop biomass above MLS from the Celtic Sea survey area (uncorrected for dredge efficiency) as a result of ordinary and universal kriging models.

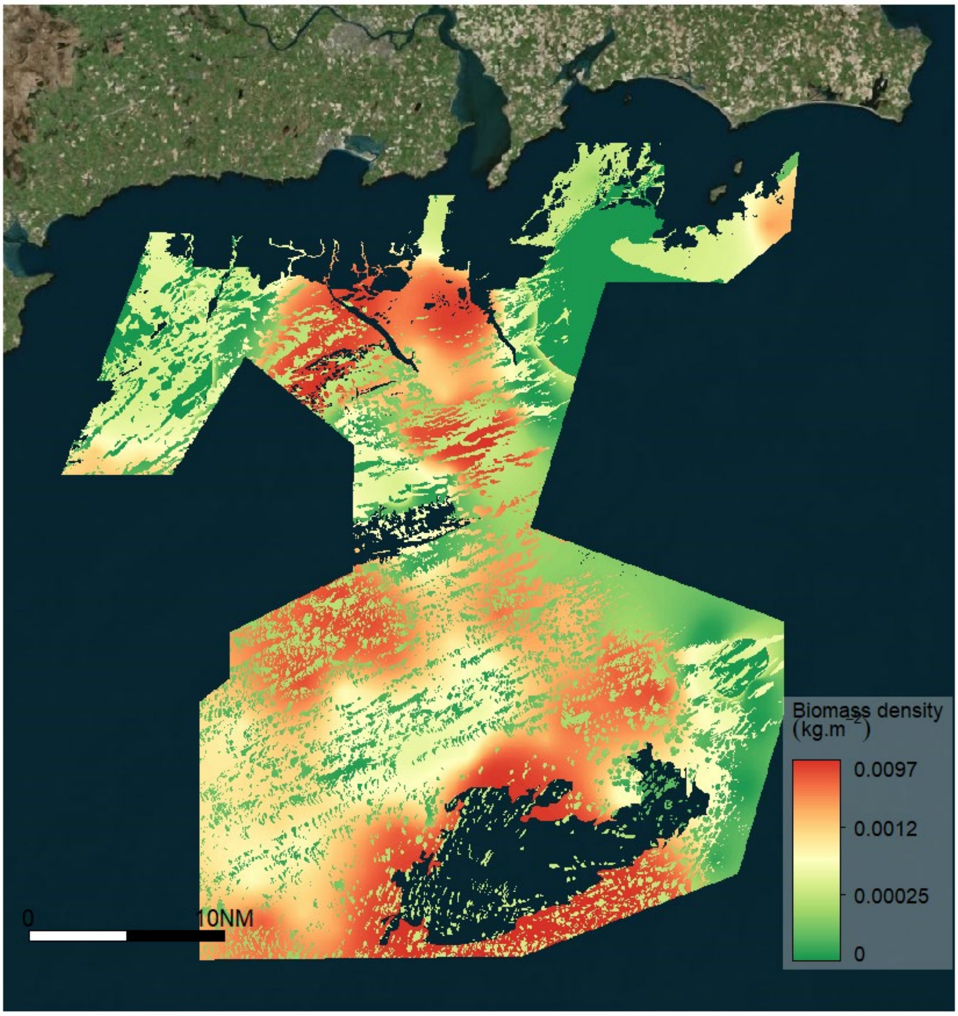

Figure 14. Biomass map for above MLS scallop produced by universal kriging with classified backscatter as a co-variable for the Celtic Sea areas surveyed in 2018 and 2019. Note the areas of rock and unclassified substrate that have been removed from analysis.

Scotland update. King scallop surveys (*Pecten maximus*)

Marine Scotland Science (MSS) has conducted dredge surveys for king scallops (*Pectin Maximus*) since the late 1980s, and typically conduct three scallop stock assessment surveys per year, covering the east coast of Scotland, the west coast and Shetland with 332 historical fixed stations. The Clyde region was sampled during an initial exploratory survey in 2019 and a second survey was planned for 2020.

In March 2020, restrictions on MS research vessels came into place due to COVID-19. Only one of the four planned king scallop stock assessment surveys was carried out. The Shetland survey was successfully completed between 25 January and 9 February 2020 before the restrictions but the East coast, West coast and Clyde surveys were cancelled.

<u>King scallops (Shetland survey)</u>

A total of 52 stations were fished covering five ICES statistical rectangles around Shetland. A total of 14 744 scallops were caught (7349 port side and 7395 starboard) in 52 hauls which were all measured, aged and assessed for shell damage. This compares to 12 040 scallops caught in 65 hauls on the 2019 survey. Scallops caught on the 2020 survey were measured from 45 to 170 mm (shell length) and aged at between two and ten years old (note that there is a plus group as scallops on MSS surveys are only aged to a maximum of ten years) with the highest number of scallops caught aged five. Two year olds were reported at 29 stations and three year olds were reported at 47 stations.

All scallops were assessed for damage. Approximately 96 % of the scallops caught had a damage index of two; meaning that the edge of the shell was chipped. The remainder were assessed as damage level three or four, meaning that the hinge was broken or the scallop was crushed or dead. There did not appear to be any spatial variation in the damage levels observed.

In addition to king scallops, 5636 other individual bycatch (minus starfish) were identified, measured and assessed for damage. The most numerous by-catch species were Queen scallops (4620 individuals), Red whelk (396 individuals) and Common whelk (212 individuals). A total of 3103 starfish were also identified to species level with the Common starfish (984 individuals), Seven armed starfish (819 individuals) and Bloody henry (427 individuals) being the most commonly caught.

Forty Scallops were collected and frozen from four ICES statistical squares for heavy metal testing as part of OSPAR assessment of hazardous substances in the marine environment. Marine litter was recorded and retained during dredging process at every station. This is done routinely as part of monitoring for the Marine Strategy Framework Directive (MSFD). Eight item of litter were recorded and retained from eight stations on this survey, including gloves, fishing nets and plastics.

<u>MSS Scallop gear comparison trial overview</u>

In addition to the four planned stock assessment surveys in 2020, a comparison trial was also scheduled to compare the N-Virodredge to the traditional Newhaven dredge.

Unfortunately, due to poor weather conditions only one day of the survey was fulfilled and only four tows completed. It is unlikely that further ship time will be available in 2021 to complete this work.

Assessment of king scallop (*Pecten maximus*) stock status in selected waters around English coasts – England (Cefas) update

Assessment plans were presented for review at WGScallop (Belfast, 2017) and subsequent annual assessments presented to the WG (York, 2018; Douglas, 2019; Video conf. 2020). In 2020, the Covid-19 pandemic severely impacted data collection from the biological sampling programme and caused a cancellation of a planned UWTV survey. Two annual dredge surveys were carried out. The first survey due in May was delayed until early August. These data will be used in the next assessment due early 2021.

Summary results from the latest available report (Lawler, A and Nawri, N. 2020) were presented to the WG and extracts from the executive summary included below:

The report describes the assessment of the status of some of these stocks undertaken annually since 2017 by the Centre for Environment, Fisheries and Aquaculture Science (Cefas) as part of a collaborative project with the UK fishing industry, the UK Department for Environment, Farming and Rural Affairs (Defra), and Seafish. Recent international landings were not available at the time of writing of this report. Harvest rates presented here are therefore provisional estimates of what will be taken from the stock over the 12 months following the survey.

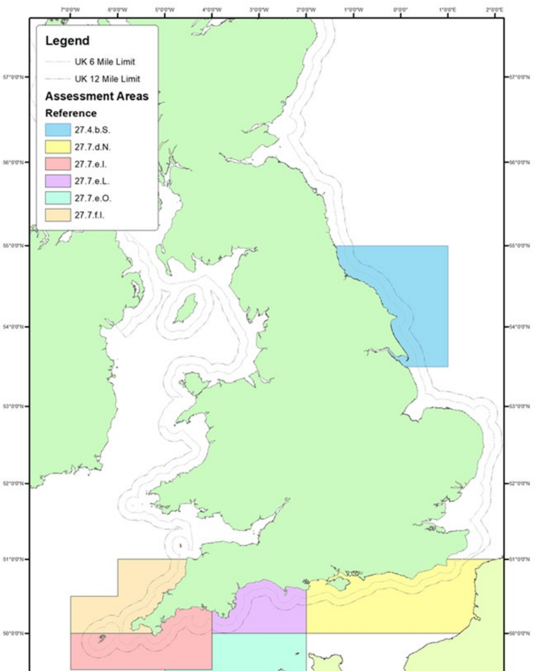

Figure 15. Stock assessment areas identified by Centre for Environment, Fisheries and Aquaculture Science (Cefas).

In 2017, five stock assessment areas were identified as being of importance to UK fisheries: three in ICES subdivision 27.7.e (Inshore Cornwall, I; Offshore, O; Lyme Bay, L) and two in 27.7.d (North, N; South, S). In 2018 two additional areas were defined, one in the approaches to the Bristol Channel (27.7.f.I) and another in 27.4.b (North Sea South, S); (Figure 15). These assignments are based on regional differences in growth and fishery exploitation patterns. Commercial landings data are available at the spatial resolution of ICES statistical rectangle, and their boundaries are used to describe the extent of the assessment areas.

This report assesses the status of the dredged portion of stocks in 7.d.N, 7.e.I, 7.e.L, 7.e.O, 7.f.I and 4.b.S, using dredge surveys, with additional estimates of unfished biomass in some parts of

7.e.I, 7.e.L, 7.e.O and 7.d.N from underwater television (UWTV) surveys. There is likely to be biomass of scallops outside those areas surveyed, for which there are no data to make any estimates.

Three data streams were used for the assessments described in this report: dredge surveys, UWTV surveys, and a biological sampling programme. Dredge surveys in the main fished beds of 7.d.N, 7.e.I, 7.e.L, 7.e.O, 7.f.I, and 4.b.S were used to estimate scallop biomass available to the dredge fishery. The scallop biomass in some un-dredged regions of assessment areas 7.e.I and 7.e.L was estimated from UWTV surveys in the first year (2017), and areas in 7.e.O, 7.f.I and 7.d.N in the third year (2019). No UWTV survey was undertaken in 4.b.S.

Estimates of harvestable biomass (i.e., biomass above minimum landing size and in areas in which dredgers can operate), and the exploitation rate experienced by harvestable scallops are covered by this assessment. However, the assessment is not able to fully estimate the impact of the fishery on the wider stock, as we were unable to estimate the scallop biomass in all un-dredged areas. Dredge surveys and catch sampling only cover the portions of stock found on the main fished grounds, as identified by the areal density of Vessel Monitoring System (VMS) pings. Harvest rate estimates from dredge surveys or commercial sampling therefore only apply to the fished portion of the stock. In situations where there are significant portions of un-dredged stock that are contributing offspring to the fished areas, any estimates of Maximum Sustainable Yield (MSY) harvest rates will, in future, need to be adjusted to compensate for this.

The potential harvest rates experienced by the surveyed portion of stocks were estimated by comparing international landings, or a proxy for them, to the available biomass estimates, either for the dredged area only, or also including the biomass from un-dredged areas (Table 7 and Figure 16).

	Provisional Harvest Rate on Dredged Portion of Stock (Dredge Survey Only, %)			**Provisional Harvest Rate for Wider Stock where UWTV available*** (Not 100% Coverage, %)**			**MSY Candidate (%)**
	2017*	2018*	2019**	2017*	2018*	2019**	
7.d.N	74.4	57.0	41.2	74.3	56.9	41.2	21.5
7.e.I	38.1	17.1	14.8	23.2	11.2	10.2	19.5
7.e.L	55.2	77.7	65.4	27.5	40.3	36.7	21.0
7.e.O	11.2	16.9	12.1	10.5	16.0	11.7	20.9
7.f.I	NA	9.6	28.3	NA	7.8	21.3	NA
4.b.S	NA	47.2	45.2	NA	NA	NA	NA

Table 7. Estimates of harvest rate from dredge and UWTV surveys, together with a candidate for MSY.

*** estimated from UK removals and average UK share, to be revised**

**** estimated from UK removals and average UK share or estimate from previous year, whichever is the highest, to be revised**

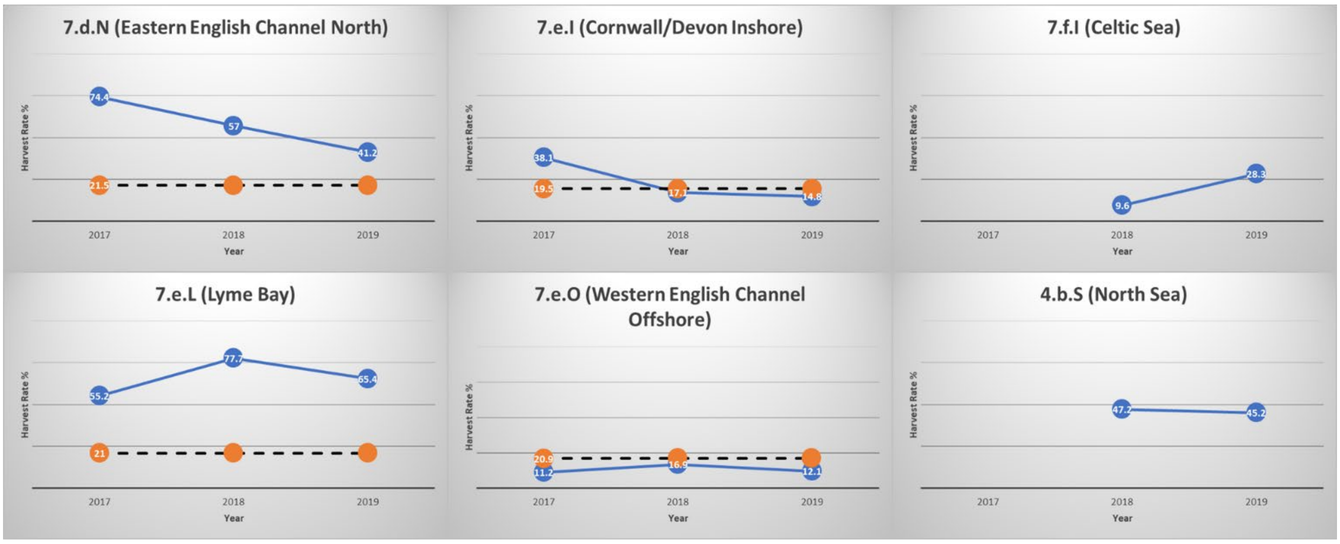

Figure 16. Trends in provisional harvest rates for four selected assessment areas in the English Channel (2017–2019), together with a candidate for a harvest rate consistent with a proxy for MSY. Estimated harvest rates for selected areas in the Celtic and North Sea (2018 and 2019).

As this is only the third scallop stock assessment, with the short time period covered by surveys, the results presented here are still preliminary. They are the start of a long-term monitoring and assessment programme, and processes and methodologies are likely to evolve in the future. As the time-series of data develops and increases in comprehensiveness, this will in turn contribute to a more robust determination of the stock status of king scallops in this region. See report for further explanation: https://www.gov.uk/government/publications/assessment-of-scallops-stocks-201819

For the 2020 stock assessment Cefas intends to use international data provided to the WG to calculate harvest rates as a measure of exploitation (Table 8).

Region	Assessment Area	Survey Year[1]	Landings (t)
North Sea	27.4.b.S	2017	2186
		2018	2594
Eastern English Channel	27.7.d.N	2017	11260
		2018	14069
Western English Channel	27.7.e.I	2017	2757
		2018	1506
	27.7.e.L	2017	1441
		2018	2195
	27.7.e.O	2017	956
		2018	1460
Celtic Sea	27.7.f.I	2017	273
		2018	148

Table 8. International landings of king scallop by selected assessment area and survey year to be used to retrospectively estimate harvest rates in the Cefas 2020 stock assessments. Source 2020 WGScallop data call (2000–2018). [1] Survey year is defined as the 12-month period after each annual dredge survey.

Reference: Lawler, A and Nawri, N. 2020. Assessment of Scallop stock status for selected waters around the English Coast 2018/2019, a Defra and Industry Funded Project. Cefas publication. 2020

Dogger Bank Fishery – England (Cefas) update. (*Pecten maximus*)

In the summer (2020) exploratory fishing by vessels on the Dogger Bank in the North Sea (Figure 17) discovered a population of king scallops (*Pecten maximus*) comprising primarily of large individuals and which provided good catch rates. As news of this resource spread there was a rapid increase in fishing effort as other vessels moved into the area to take advantage of good catches.

The fishery started in June and was primarily targeted by nomadic Scottish dredgers. Anecdotal information from fishers suggested that the catch was primarily composed of ripe and mature animals ready to spawn and this led to requests from the industry for the fishery to close until the scallops had spawned.

Six ICES statistical rectangles were targeted (37-39F1-F2) although the resource was typically aggregated in some areas. Provisional landings of king scallops show the increase in 2020 (Figure 18).

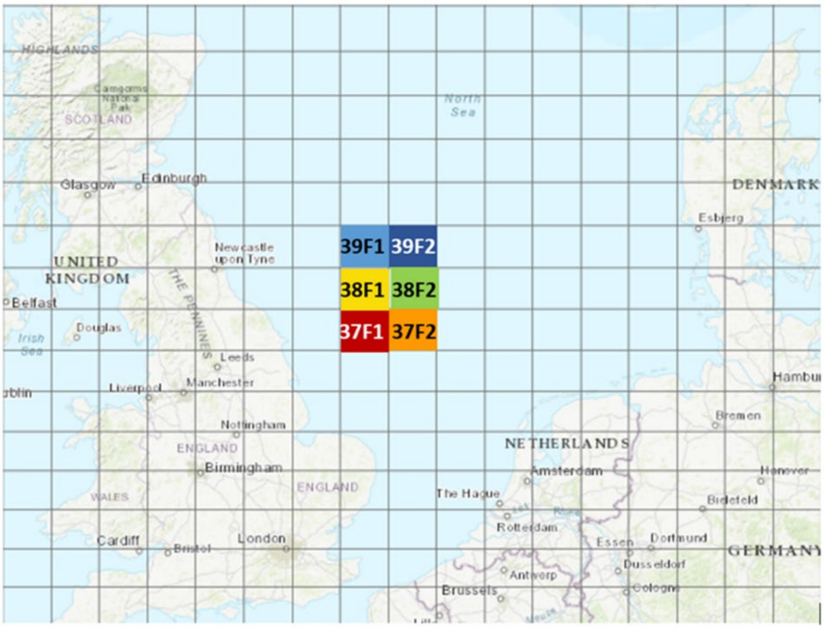

Figure 17. Dogger Bank ICES statistical rectangles.

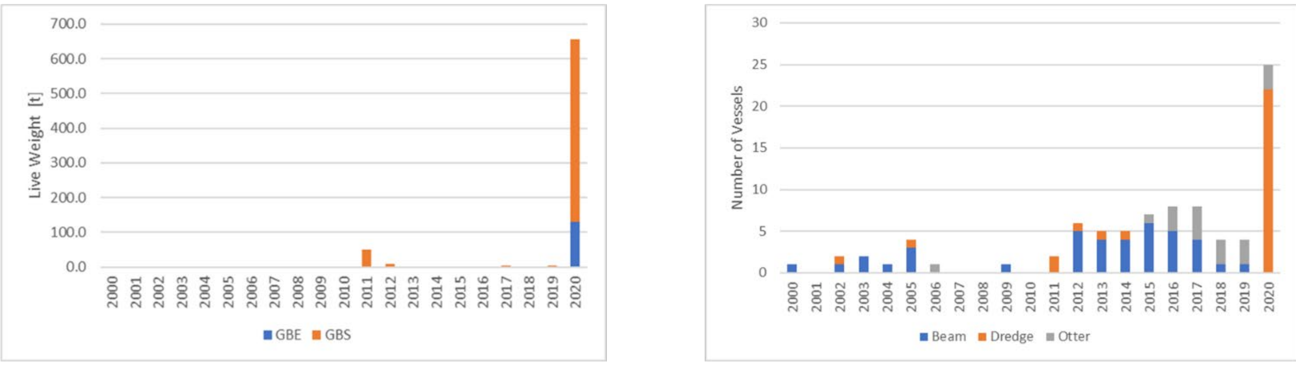

Figure 18. Annual king scallop landings (t) for Dogger Bank and total vessel numbers with landing from associated ICES statistical rectangles 2000–2020 (2020 incomplete).

The fishery was closed on 12th July and there was a requirement to provide evidence to support the closure and to inform fishery managers when the scallops had spawned, and the fishery could be reopened. The ICES rectangles on the Dogger Bank are not currently included in the Cefas assessment programme and biological information such as spawning times were not available. The RV *Cefas Endeavour* carried out a survey on Dogger Bank in early August and this confirmed that most of the scallops in this area were approaching spawning condition or were ready to spawn. Samples taken during the survey highlighted a high proportion of the scallops were from the 2014-year class.

A 2nd survey was planned for September with the anticipation of demonstrating that spawning was underway or peak spawning had occurred. However, the 2nd survey was cancelled due to issues with the Covid-19 pandemic and the fishery closure was extended to the 11th October as a precautionary measure. *Update:* In the absence of further evidence representatives of the fishing industry have voluntarily agreed to an extension of the closure to 1st March 2021. We anticipate a requirement to create an additional assessment area in the North Sea and expand the spatial extent of the annual dredge survey to include this area in the future.

King scallop (*Pecten maximus*) in the Bay of Saint-Brieuc (VIIe, 26e7). Survey COSB 2020 (September 2nd-16th). Results and management projections

Ifremer carried out the yearly directed stock assessment for the inshore King Scallop fishery of the Saint-Brieuc Bay (VIIe, 26e7) extended to 634 km² of total surface divided in six spatial strata (survey COSB2019; French R/V "Thalia"). The COVID-19 emergency affected a lot of stock surveys although the one planned for the Saint-Brieuc Bay was undertaken in the initially scheduled period of early September.

The onboard operations usually undertaken in the late summer involve in sampling 115 stations by dredging on constant distances of 200 m using an experimental dredge of 2 m width equipped with a pressure plate (Breton dredge), teeth of 8.5 cm length and belly and back ring diameter of 50 mm. The dredge efficiency is calibrated owing to previous references (Fifas and Berthou, 1999; Fifas *et al.*, 2004). Caught individuals are exhaustively aged and a LFD by age group and by tow is obtained.

The inshore king scallop fishery of the Saint-Brieuc Bay is probably represented by the highest density levels in European scale. For the period 1962–2019, landings usually oscillated in a range of 4000–6000 t with some extreme values as 12 500 t (season 1972/73) and 1300 t (season 1989/90). In recent years, the exploitation has been undertaken by 220–230 vessels (98% dredgers, 2% divers). Many historical stages throughout more than a half century of exploitation (from the early 60s onwards) show the vanguard position of this stock for the scallop French fisheries: licence system by pair skipper/vessel, global quota/TAC, obligation of landings at auction, improvement of selectivity pattern.

The adult biomass includes all age groups 2 and +, it provides an index of the potential fecundity of the stock. The exploitable biomass corresponds to individuals larger than 102 mm (MLS in VIIe French waters), thus it is a fraction of the adult one. Those indices show cyclical pattern with a downwards trend in the period 2006–2013 (respectively -53% and –57% for adult and exploitable biomass). Afterward, an increasing phase is obvious. Since 2018, the stock has steeply increased. In 2020, the absolute records for adult and exploitable biomass were reached (respectively +54% and +43% compared to 2019).

The recruiting class abundance is estimated at 152 million (14 210 t, among them 7750 t immediately exploitable). This value is the historically highest level although accordingly to the last year's survey it was expected that the abundance of this class should be lower (101 million; based on relationship abundance GR2 *vs.* GR1 for a same cohort). Moreover, in the last year's survey the recruitment abundance estimated at 81 million was expected to be much higher (135 million). The reasons for those deficiency and excess on two subsequent years were debated: probable ageing errors (overestimation for the first survey, underestimation for the second one), excessive direct (illicit catches) or indirect (damaged scallops) fishing pressure in the first year associated to a fall of the fishing activity for the second year due to the COVID-19 disruption, but no explanation seems to be solely a key factor.

The management policy consists to preserve more than one significantly abundant age groups at the aim of reducing fluctuations between yearly total abundance as more as possible independently of the annual recruitment variability. Four age groups are significantly abundant in the fishery: 3–6 years (respectively 13 970 t, 10 610 t, 8520 t, 6120 t). The total remaining biomass was estimated at 37 050 t (26 930 t in 2019). The cohort 2017 is represented by a total abundance of 111 million (strongest value throughout the overall time-series), among them 71% reached the MLS=102 mm (10 740 t on a total biomass of 13 970 t).

In September 2020, the age group 1 was estimated equal to 417 million individuals (this abundance should provide a total one of 163 in the next year's survey). As for other stock indicators, this value is the maximum historical level: it is noticeable that the majority of historically high reproductions (cohorts 1973, 1999, 2005, since 2016) occurred during the last two decades of the stock history. The mean size of this year class was 67 mm (length) against 66 mm a year ago for the cohort 2018.The year class abundances (2020–2022) are not currently known. The 2020s cohort abundance will not be reliably estimated before the late summer 2021 as the spat collectors used in summer 2020 provide a minor part of explanation for the future class strength. The input values for those three classes will be simulated. The simulation takes into account that a Ricker S/R model explains a very low ($\varrho^2 \approx .115$) part of the predicted cohort abundance. The uncertainty in this relationship can be expressed by a log-normal probability. On this basis, recruitments for cohorts 1989–2019 (surveys 1990–2020) are assigned to probability levels against the spawning biomass[1] of the birth year.

There is no other surveyed species or stocks in French fisheries with possibility of reliable projections on three years. The partnership scientists/fishing industry (project FEAMP 28 on years 2017–2019 extended to the period 2020–2022) consists to guarantee the durability of the whole study. In this partnership, the survey at sea provides accurate estimates for GR1+ whereas the age-size structured stratified biological sampling on landings allows to calculate all fishing mortality components for GR2+ and the spat collectors for GR0 gives the first semi-quantitative estimate by cohort.

The management regulations allow to smooth decreasing patterns when the unavoidable weak cohorts arrive although the cannot completely change neither cyclical phenomena nor the global warming trend.

							Log-normal p=0.5			Cyclical log-normal p		
Option	Quota	Landings	Δf (%)	ΔY1 (%)	ΔY2 (%)	ΔY3 (%)	ΔBf1 (%)	ΔBf2 (%)	ΔBf3 (%)	ΔBf1 (%)	ΔBf2 (%)	ΔBf3 (%)
1	5840	6714	0.0	25.8	20.8	13.4	6.1	-1.3	-17.1	6.1	0.7	-12.8
2	5664	6544	-2.9	22.6	21.6	13.9	6.6	-1.0	-16.7	6.6	1.0	-12.5
3	6300	7157	7.6	34.1	18.8	12.2	4.8	-2.3	-18.1	4.8	-0.3	-13.7

Table 9. Numerical application for the 2020/21 season's proposed quota. 1st column: proposed quota(t); 2nd column: actual nominal landings (t); 3rd column: Δf=% variation for fishing effort between 2019/20 and 2020/21; 4th to 6th columns: ΔY1, ΔY2, ΔY3=% variation of landings between subsequent fishing seasons; 7th to 9th columns: ΔBf1, ΔBf2, ΔBf3=% variation of spawning biomasses between springs/summers of subsequent years.

References : Fifas S., Berthou P., 1999. An efficiency model of a scallop (*Pecten maximus*, L.) experimental dredge: Sensitivity study. *ICES Journal of Marine Science, 56*: 489-499.

Fifas S., Vigneau J., Lart W., 2004. Some aspects of modelling scallop (*Pecten maximus*, L.) dredge efficiency and special reference to dredges with depressor plate (English Channel, France). *J. Shell. Res., Aug. 2004; 23 (2)*: 611-620.

Norway update. King scallop (*Pecten maximus*)

Exploitation of the king scallop *Pecten maximus* in Norway was originally impeded by the unfavourable bottom conditions for dredging. A commercial diver-fishery on king scallop was developed in Norway during the early 1990s in the main fishing areas west of Trondheim (64°N), and data on catch appeared from a statutory marketing data. Since 1999 the catch has been 400–

[1] The spawing biomass differs from the adult one because it is calculated by weighing accordingly to the number of eggs potentially produced which is a function of the scallop size.

900 t (Figure 19) with an equivalent value of €2–3 million euro. During the recent 3–4 years landings have increased in the county of Nordland, north of Trøndelag. In 2019, the landings were of 447 t.

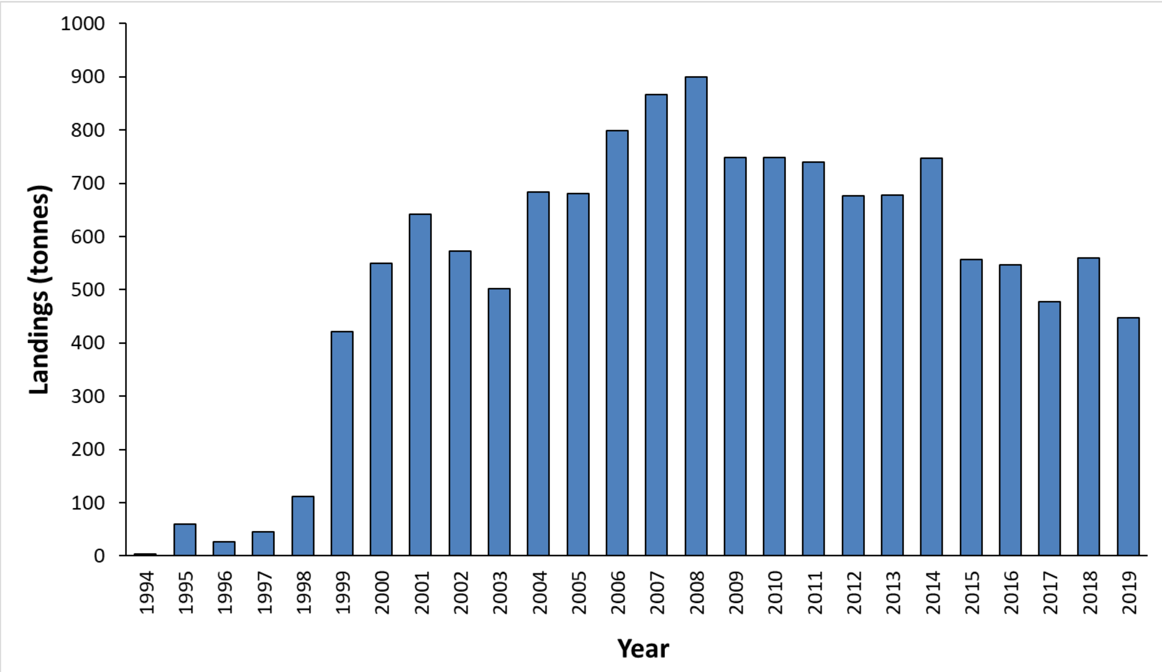

Figure 19. Landings of king scallop (*Pecten maximus*) into Norway by divers in the period 1994–2019.

Since the fishery developed, the possibility of over-exploitation of the harvestable stock has been an issue of concern. The fishery was initially unregulated, although the sale of scallops was regulated through licensed distributors. The increase in diver participation in the scallop fishery between 1998–2000 encouraged the Norwegian Labour Inspection Authority to set new certification requirements for commercial scallop divers. This restricted the recruitment of diver-fishermen and contributed to regulating the fishing effort. Based on input from a reference group representing industry, management authorities and research, a minimum landing size of 100 mm shell length was implemented in 2009 for both commercial and leisure catches. Suggested management measures on the introduction of closed areas were rejected based on cost-benefit considerations of enforcement and an appraisal of the existing rotational fishery between areas pursued by the main harvesters. The anecdotal experience was that the harvestable stock was restored after two to four years. It is unclear to what extent restoration of the stock is caused by growth into legal size and/or migration of scallops from deeper beds, the latter being contended as dominant by the fishermen.

The Institute of Marine Research (IMR) has irregularly since mid-1990s surveyed the fished stocks to assess age distribution. Data on individual diver catch- per day (CPUE) has been extracted from logbooks during the period 2003–2011 and data on regional catch are collected from the statutory marketing data. These data are used to advise on the king scallop stock.

As a part of the "National marine habitat mapping program" areas of high abundance of the great scallop *P. maximus* has been mapped in Norwegian coastal areas. The scallop beds were mapped using a vessel-towed camera platform collecting real-time video along survey lines. The position of the lines was chosen combining topographic information from sea maps with anecdotal knowledge about scallop distribution patterns. During 2009–2019 data from a total of about 850 tows from Rogaland County (South-Western Norway) to Nordland County (North Norway) have been obtained and analysed.

The last IMR diving survey in the main fishing area of Frøya/Hitra in Trøndelag was conducted in 2010. In 2017 and 2018 diving and video surveys were conducted on the northernmost registered king scallop populations in the Lofoten area. In 2019 and 2020 there was no survey activity, due to limited resources in the project. In 2021, plans are to do a diver survey in the Frøya/Hitra area in April. However, due to the latest regulations of scientific diving a functional diving team may not be at hand. As this probably will be a challenge also in the future, alternative survey methods are discussed such as video surveys, obtaining scallop age data from shellfish distribution companies, develop bottom gear for use in areas with a high degree of variation in topography and type of sediment or use ROV for both video recordings and collection of scallops.

Data on individual diver catch- per day (CPUE) has been extracted from logbooks during the period 2003–2011 and data on regional catch are collected from the statutory marketing data. These data are used to advise on the king scallop stock. Logbooks for the period 2011–2016 will be punched and analysed in 2020/2021. Since 2016, catch has been registered per boat, which makes it challenging to calculate the effort per unit (e.g. diver).

Assessment of king scallop stock status in the Bay of Seine – Normandy, France (Ifremer) update

Each year, Ifremer processes the assessment of the king scallop stocks in the Bay of Seine, the most important seabed for king scallop in Eastern Channel. For that, Ifremer's scientists use the R/V Thalia, and conduct around 160 sampling stations, 60 outside the French territorial waters in a box between the 12 miles limit and the parallel 49°42N (Figure 20).

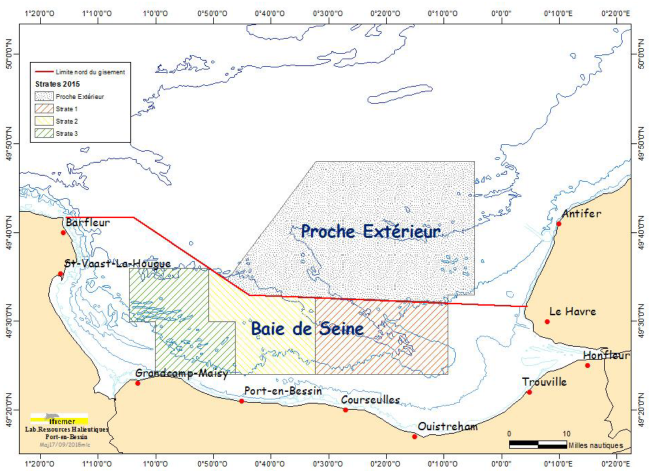

Figure 20: Prospected area in the Bay of Seine during COMOR surveys.

This year, because of the COVID-19 pandemic, the planned survey in July was cancelled. To maintain the continuity of the time-series, a substitution survey was undertaken on a small industry vessel, "Le Tourville", a dredger from harbour of Dieppe. The scientific protocol remained the same, but the number of sampling points was reduced, and focused on the Bay of Seine within the French territorial waters, which constitutes the main fishing area for the French fleet (Figure 21).

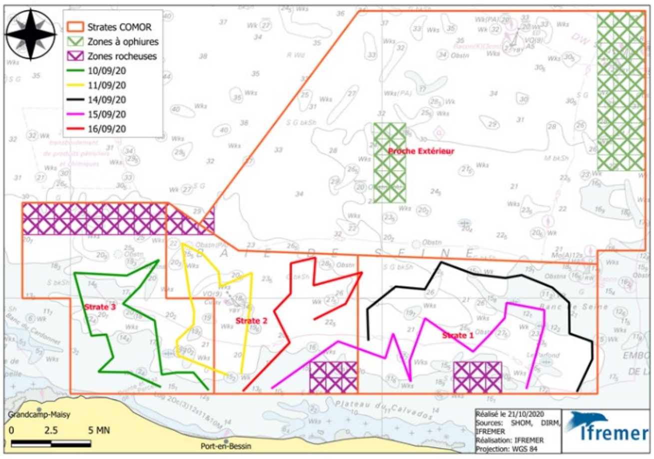

Figure 21. Prospected area during 2020 assessment survey on-board F/V Le Tourville, September 2020.

Results

Estimated abundance indexes are given in the table 10 below.

Indices	1 an	2 ans	3 ans	4 ans	5 ans	6 ans	7 ans	3 ans+	2 ans+
2017	569.99	705.88	51.35	7.21	1.86	0.57	0.26	61.26	767.14
2018	394.33	789.08	175.63	17.64	1.24	0.24	0.20	194.96	984.04
2019	297.80	212.39	110.75	25.92	2.13	0.21	0.02	139.03	351.42
2020	640.32	533.60	186.65	62.10	10.57	0.81	0.16	260.29	793.89

Table 10. Abundance indexes in the bay of Seine, September 2020 (Total number of King scallop per 3704 m², corresponding to the standardize length (one mile) of the tow x sampling dredge width (2 meters)).

The indexes of the three exploitable cohorts (ages 2, 3 and 4) are very good, and much higher than the 2010–2019 average indexes (Figure 22). The recruitment (age 2) is a little bit less than 2017 and 2018 recruitment, but is the third higher of the time-series since 1980. The biomass of adults scallops (age 3 and more) is the best observed since the beginning of the time-series.

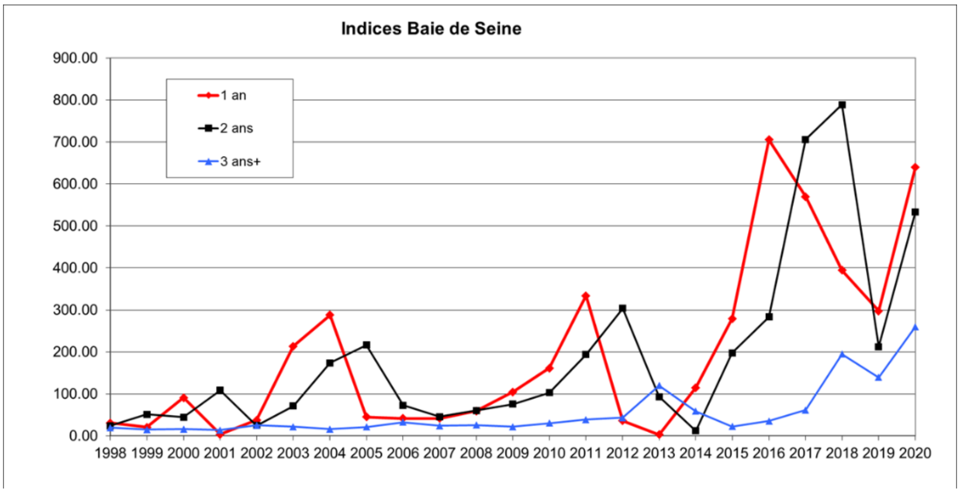

Figure 22. Trends in king scallop abundance indexes, by age, in the bay of Seine.

The exploitable biomass of the bay of Seine is estimated to be 52 949 t (Figure 23). It is the second highest value of the time-series.

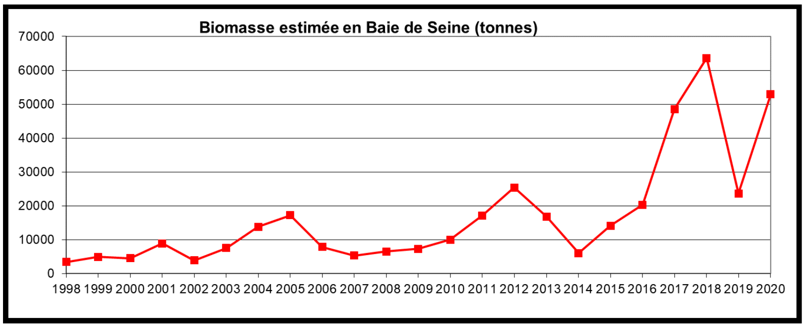

Figure 23. King scallop exploitable estimated biomass in the bay of Seine.

The observed growth of different ages is similar to those observed in previous years (Figure 24). The difference observed for age 1 is only due to the period of the assessment survey, usually done early July, but realised mid-September this year (survey delayed because sanitary constraints).

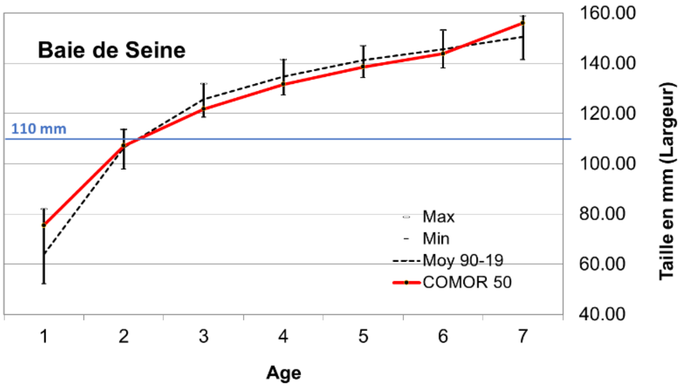

Figure 24. King scallop growth curves in the bay of Seine (September 2020).

The distribution of the different ages in the bay of Seine shows that the density of king scallop is higher in the western part of the Bay (Figures 25, 26 and 27).

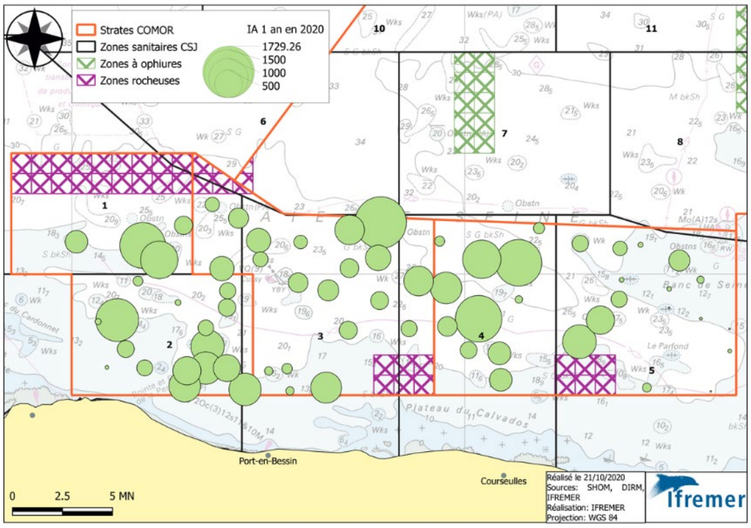

Figure 25. King scallop distribution (age 1 - juveniles) in the bay of Seine (September 2020).

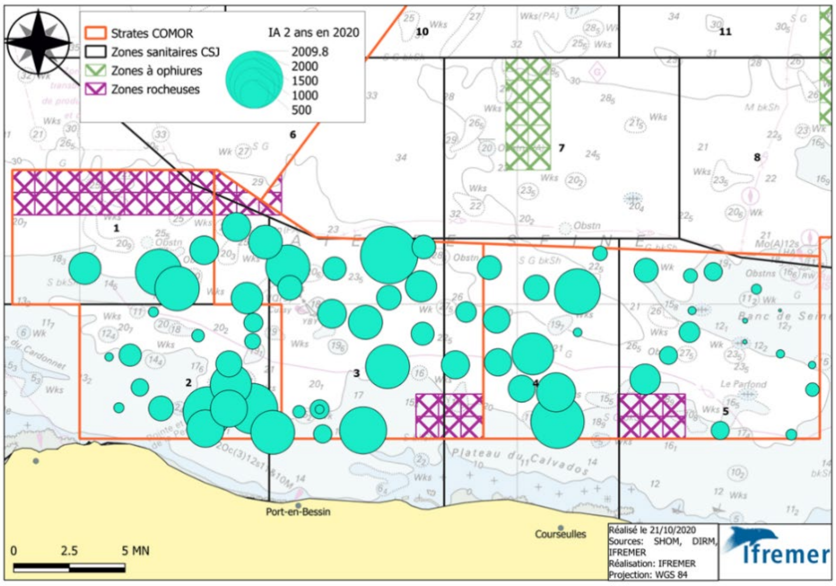

Figure 26. King scallop distribution (age 2 - recruitment) in the bay of Seine (September 2020).

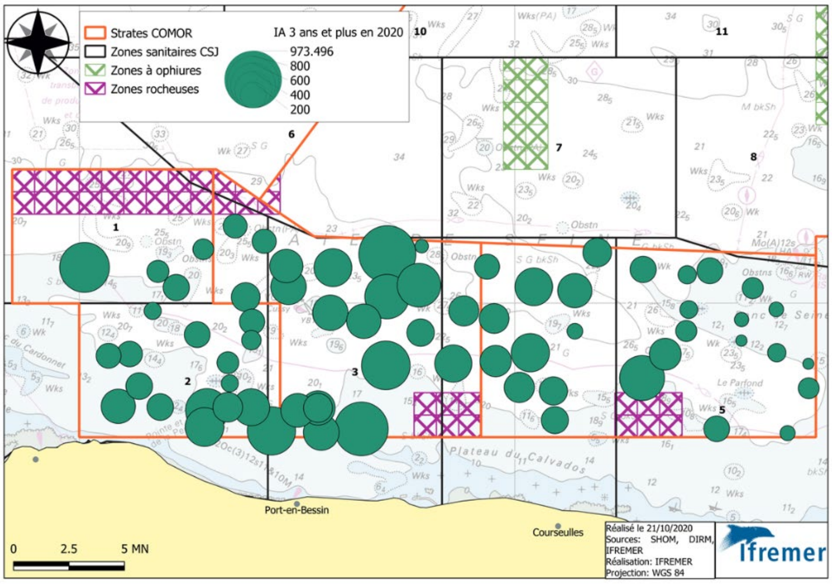

Figure 27. King scallop distribution (age 1 - adults) in the bay of Seine (September 2020).

The Bay of Seine is administratively divided into five areas (black grid in the maps above) for the monitoring of toxic algae. According to the results of the survey, French industry and administration have decided to leave all of Zone 4 for the entire fishing season as biological management measure (rotational management).

Queen Scallops

This year the WG decided to focus on the queen scallop, ***Aequipecten opercularis*** and discussed most of the ToR with relation to this species.

The queen scallop (*Aequipecten opercularis*) is smaller than the king Scallop, typically growing to approximately 100 mm shell length. Both shells of the queen scallop are convex, although the left valve is more curved. The colour of the shell varies, but tends to be shades of yellow, orange or red which are sometimes mottled. Both shells are marked with about 20 radiating ridges and corrugated concentric groves which leave the margins of the shell crenulated. The queen scallop occurs on substrates similar to that of the king scallop but as it does not recess into the seabed it can also live on harder substrates. Queen scallops can swim much more actively than king scallops. Queen scallops mature at around 1–2 years.

Provisional landings of queen scallops are highest from ICES sub area 7 and between 2000 and 2019 reveal a peak in 2011 with over 23 000 t but have since declined to just over 6000 t in 2019 (table 11). Note that there are problems with the data collated from the data call – please read the issues identified under ToR a.

Landings of queen scallops into UK ports also show a decline from a peak in 2011 with only 2750 t landed in 2019 (Figure 28). In 2012, UK queen scallop landings were reported from 38 ICES rectangles with high volumes coming from 39E3, 39E4 and 40E4 as well as within the Irish Sea. In 2019, zero landings were reported from these areas and the fishery was focussed in the Irish Sea (Figure 29).

Year	4	6	7	8
2000	105.4	1.8	5103.7	19.4
2001	159.1	99.9	9616.9	17.6
2002	61	4639.1	11426	49.1
2003	22.8	1226	11494.7	43.2
2004	33	1397.5	7127.2	63.5
2005	18.5	1231.2	9005.9	74.4
2006	21.7	1256.7	8955.7	110.7
2007	12	63.6	13112.4	60.1
2008	9.2	201.7	5258.6	51.6
2009	16.2	1849.4	5606.1	91.5
2010	11.3	2971.9	12691.8	116.3
2011	11.1	3002.1	23519.7	130
2012	36.4	4916.8	17334.2	35.4
2013	20.9	1909.1	18862.5	25.2
2014	8.8	944	11002.3	47.7
2015	17.5	89.9	14504.9	75.8
2016	1238	134.7	10971.9	175.8
2017	141.2	215.1	10475.4	197.6
2018	68.2	75.9	9195.5	134.6
2019	34.1	0.4	6095.7	78.5

Table 11. Provisional total landings (live weight, t) of queen scallops by ICES area and year 2000–2019. Data from data call. Note that Isle of Man data are missing prior to 2011 and Scottish data are missing prior to 2003.

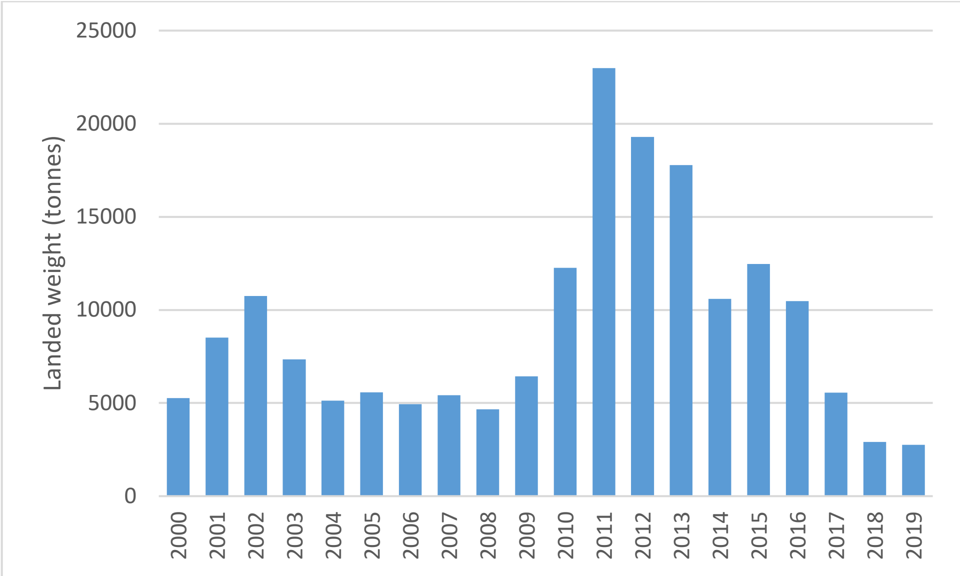

Figure 28. Provisional landings of queen scallops, *Aequipecten opercularis*, into UK ports between 2000 and 2019. Data from iFish database. Note that Isle of Man data are missing prior to 2011.

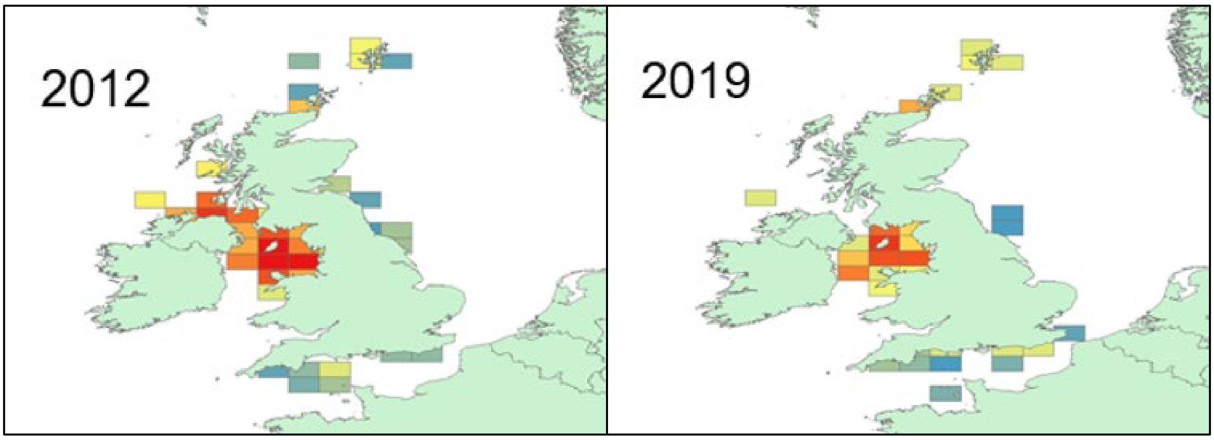

Figure 29. Location of queen scallop landings into UK ports, by ICES rectangle in 2012 and 2019.

The North West Groundfish survey (NWGFS) part is an annual survey conducted by Cefas in September which covers areas of the Irish Sea (27.7.a), Bristol Channel and Celtic sea (27.7.f and g) (Figure 30). The survey gear is a 4m beam trawl with chain mat and flip up ropes, the net is fitted with 40 mm cod-end liner. Catch, length (all species) and biological data (selected species) are collected on each survey. Benthic, litter, water temperature, salinity and acoustic data are also collected when possible. From 1988 to 2017, queen scallop (*Aequipecten opercularis*) were counted and weighed at approximately 20 key selected positions ("Benthic stations") out of 108 full survey tows. At the remaining tow positions queen scallop were reported as absent or present. In 2018, queen scallops were weighed and counted at all stations (108 stations) and in 2019 a total of 2001 queen scallops were measured (shell height). Moving forward length samples of queen scallop will be a requirement of the sampling procedure for this survey.

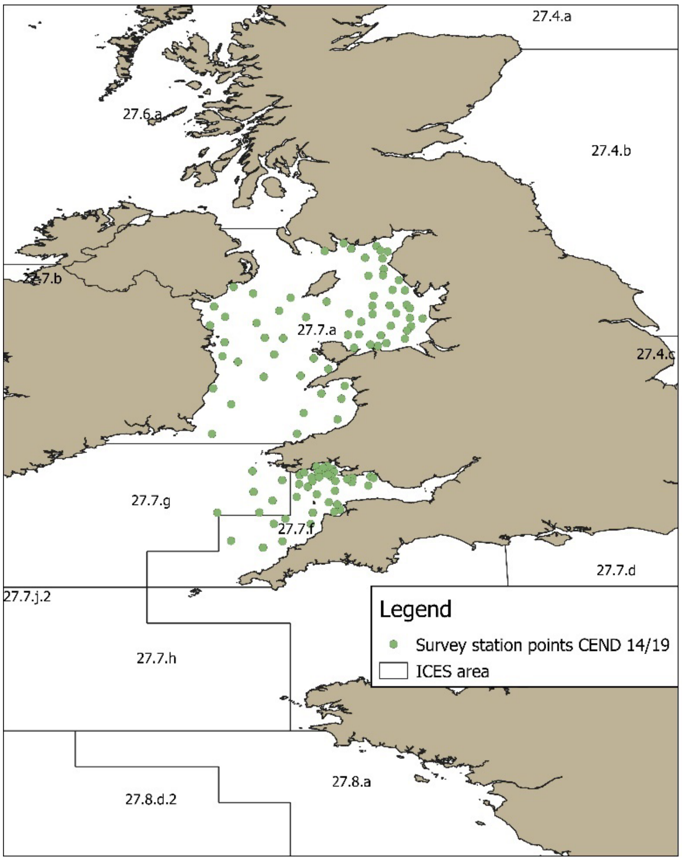

Figure 30. Station points of the North West Groundfish Survey (NWGFS) CEND 14/19 in 2019 (Cefas).

The length distribution shows two peaks, one from 34mm to 55mm and another smaller peak from 60mm to 70mm. The highest number of individuals measured 45mm (1089 individuals). 14% of queen scallops measured were below or equal to 40mm (UK MLS) and 91% of the queen scallops measured were below or equal to 55mm (IoM MLS); (Figure 31).

The WG discussed that the queen scallop length frequency distribution appears quite different to that observed on the other dedicated scallop surveys (which are primarily using dredges). This will be further examined by the sub group (details provided below) and will report to the WG next year.

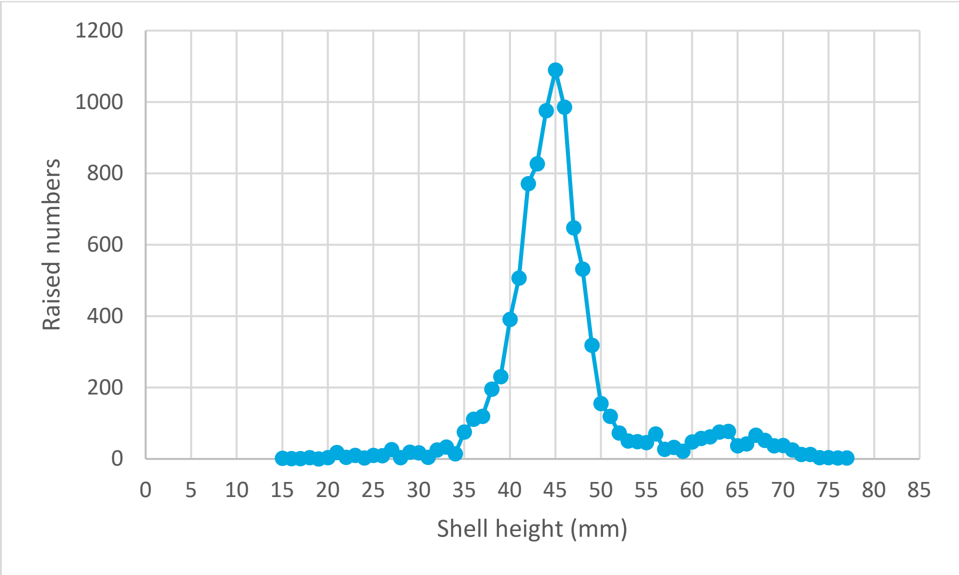

Figure 31. Length frequency distribution of queen scallops from the NWGFS CEND 14/19 in 2019 (Cefas).

The ICES WG Scallop is starting to look specifically at queen scallop stocks and fisheries in more detail for the first time this year. To progress collaborative research and knowledge of this species and fishery it was proposed that the WG contributes to a manuscript combining data and knowledge of queen scallops across the entire ICES distribution area. A number of institutes already collect data on queen scallops and there was agreement that a sub group should be established to progress this work area. A biological sampling program within the WG will be set up to collect samples via surveys or processors from each ICES area to enable age, growth and other biological parameters to be assessed and compared across the distribution area. These key biological and population parameters will also enable stock assessments based on age as well as length to be developed in the future. Expertise within the WG and from the scallop ageing workshop will be used to develop a standardised approach to ageing queen scallops. In an effort to foster multi-institutional collaboration and bring additional capacity to this task, Dave Rudders offered to examine a sample of shells to provide methodological input on the initiation of an aging effort. Environmental links to variation in growth rates and other parameters will be explored as part of the manuscript. A subgroup of members has been established to progress this ToR and the collaborative manuscript with a plan to meet before the end of this year.

2.5 ToR e) Continue to refine stock structure using best available information on genetics and larval dispersal and look to improve current mapping of scallop stocks

An update was given to the WG about recent research, both published and under review, regarding genetic and modelled physical larval connectivity between scallop populations in locations around Europe.

A recently published paper (Handal, W., Szostek, C., Hold, N., Andrello, M., Thiébaut, E., Harney, E., Lefebvre, G., Borcier, E., Jolivet, A., Nicolle, A., Boyé, A., Foucher, E., Boudry, P., Charrier, P. (2020). **New insights on the population genetic structure of the great scallop (Pecten maximus) in the English Channel, coupling microsatellite data and demogenetic simulations**. *Aquatic Conserv: Mar Freshw Ecosyst.*30: 1841–1853) analysed the genetic structure between major fishing grounds across the English Channel using 13 microsatellite loci. Coupling empirical genetic data with demogenetic modelling based on a biophysical model simulating larval exchanges among scallop beds, revealed a subtle genetic differentiation between south-west English populations and the rest of the English Channel, which was consistent with larval dispersal simulations. These findings indicate that, even in a context of potentially high gene flow and recent divergence times since the end of the last glacial maximum, weak but significant spatial genetic structure can be identified at a regional scale and aids in the definition of management units.

At the scale of the British Isles, no significant genetic structure has previously been detected, regardless of the genetic markers employed (i.e. allozymes, mitochondrial DNA, microsatellite markers, singlenucleotide polymorphisms; Beaumont, Morvan, Huelvan, Lucas, & Ansell, 1993; Morvezen, Charrier, *et al.*, 2016; Vendrami *et al.*, 2017; Wilding, Beaumont, & Latchford, 1999), apart from in Mulroy Bay (North of Ireland), suggesting that P. maximus forms a single panmictic population. The present study revealed different population structure patterns compared with those previously reported (Morvezen, Charrier, *et al.*, 2016; Szostek, 2015). Weak population genetic differentiation was observed within the English Channel between the south-western English (SWE) coast and the rest of the English Channel.

This is congruent with the larval dispersal model from Nicolle *et al.* (2016), which showed a lack of larval connectivity between SWE and the rest of the English Channel. In certain areas, a refined sampling design combined with fine-scale larval dispersal modelling seems required to better understand possible restrictions to larval connectivity; such as around the tip of Brittany that may isolate the Bay of Brest from the Ushant Sea and the Western English Channel. It is important in a management context to make the distinction between gene flow and larval dispersal, i.e. between genetic and demographic connectivity. It is unlikely that the number of effective migrants contributing to the genetic homogeneity across the English Channel would be enough to maintain demographic connectivity between the Eastern and Western English Channel, supporting the need for different management strategies.

Research currently under review for publication by Hold, N. *et al.* investigated how populations of a broadcast-spawning marine species (*Pecten maximus*) that occur in discrete geographic locations were connected to each other. Population genetic insights were related to the outputs from a three-dimensional hydrodynamic model implemented with scallop larval behaviour to understand the extent to which these areas were linked by oceanographic processes and how this was altered by season and two contrasting years (warm vs. cold). Connectivity was high at a regional level (e.g. northern Irish Sea), but lower at scales > 100 km between sites. Some localities were isolated and thus dependent on self-recruitment to sustain local populations. There was evidence for both bi- and uni-directional movement of larvae, indicating sources and sinks. Although genetic data suggests populations around the Isle of Man are connected, in some cases the probability of larval exchange was less than 10% per spawning event which could be high enough for populations to maintain genetic connectivity but may not be sufficient for populations to rapidly recover via immigration if over-exploited. In the English Channel, both oceanographic distance and modelled connectivity fail to explain the patterns of genetic differentiation, which could be due to a number of processes (sampling resolution, stepping-stone dispersal, the timescale over which populations with shared ancestors diverge allele frequencies, chaotic genetic patchiness). Seasonal timing of spawning and inter-annual fluctuations in seawater temperature influenced connectivity patterns, and hence will affect recruitment within a network. Summer rather than spring spawning increased connectivity among some populations, due to the seasonal strengthening of temperature-driven currents. Furthermore, the warm year resulted in higher levels of modelled connectivity than the cold year. The combination of genetic and oceanographic approaches provided valuable insights into the structure and connectivity at a continental shelf scale. This insight provides a powerful basis for defining conservation management units and the appropriate scale for spatial management.

The WG were also made aware of two new PhD projects that are starting in Scotland. One project aims to investigate the population genetic structure and diversity of scallops around Scotland and to better understand the connectivity between patches. The second project will attempt particle tracking modelling to quantify connectivity and also investigate scenarios of spatial closures. Both students will be approached and asked to provide an update to the WG at next year's meeting.

2.6 ToR f) Keep current biological parameters under review and update when more information becomes available and report on all relevant aspects of: biology, ecology, physiology and behaviour, in field and laboratory studies

In 2017, a study commissioned by Seafish and undertaken by the Agri-Food and Biosciences Institute (AFBI), on behalf of the Northern Ireland Scallop Association, highlighted four potential sites around the Northern Ireland coast for scallop reseeding. To ensure sites selected for enhancement are given the best chance of success, a desktop study has been prepared by AFBI (again through Seafish funding) to assess further the possibility of scallop enhancement including the benefits and negatives of such a scheme. A review of literature (100+ papers) on scallop enhancement initiatives was carried out, providing examples of the scallop enhancement techniques used in eleven countries (Northern Ireland, Isle of Man, England, Scotland, Ireland, Japan, China, France, America, Canada and New Zealand) and includes cases of closed areas, reseeding and sea-ranching. Based on the literature, a list of pros and cons was prepared for closed areas and reseeding (Tables 12 and 13 below).

This study led to a number of recommendations being made to the NI Scallop Association.

1. The closure of key areas for the purposes of scallop enhancement should be treated as an initial step, with closures to mobile gear as well as hand collection (diving) of scallops.
2. Further enhancement strategies, such as reseeding could be implemented. However, knowing the potential negatives associated with reseeding, it is recommended that not all sites are reseeded. This would provide a unique comparison to glean the real benefit, if any, that reseeding has over a simple area closure.
3. Sites must be monitored to determine success or failure.

This work with be further supplemented by an additional work package which will use hydrodynamic modelling to examine larval dispersal from the proposed enhancement sites, providing a clearer indication of where scallop larvae would expect to settle and if this will benefit the scallop fishery.

The full report will be available on the Seafish website or by contacting Carrie McMinn (AFBI) **carrie.mcminn@afbini.gov.uk** or Annika Clements (Seafish) Annika.Clements@seafish.co.uk

	Pro	Con
Biological	Increased densities of scallops	Dispersal of adults (spillover) unlikely as scallops sedentary
	Eliminate mortality of scallops and other species from indirect damage by fishing gear and discard/bycatch mortality.	Potential for mass mortalities, possible crowding (limiting recruitment and growth), increased predator densities, and increased frequency of disease (Stokesbury, 2015).
	Increased settlement substrate and refuge for juvenile animals	Larval retention in area would mean no benefit to the fishing grounds outside the closed area
	Potential dispersal of scallop larvae to fishing grounds "larval dispersal"	May take several years before any benefits are noted.
	Protection/restoration of habitat – increased habitat complexity	Carrying capacity of an area will eventually be reached (Lizaso *et al.* 2000).
	Increased reproductive output	
	Increase in size and age of scallops	
	Improves habitat for scallop settlement	
	Restore natural population structure	
	Potential to increase biodiversity	
	Protection of spawning sites	
	By protecting natural supply of larvae can maintain genetic structure of the area.	
Social	Reduce conflict between fishing gears.	Displacement of fishing
	Provide study areas for natural processes which can feed in to protecting the stock through stock assessments.	Illegal fishing on high density grounds
		Assessment of benefits can be difficult.
Economic	No cost associated with maintaining closed area	Enforcement costs
	No labour of site required unless for removal of starfish	
	Does not require detailed stock/ system data (Ward *et al.* 2001).	

Table 12. Pros and cons associated with closed areas for scallops.

	Pro	Con
Reseeding general	Increases density of scallops quickly.	Predation or reseeded spat
	May be useful at estimating biological parameters used in stock assessments, such as natural mortality.	
Collecting seed using spat collectors	Provides settlement substrate in areas which have been disturbed and settlement substrates are not naturally present	Cost associated with spat collectors
	Should have no impact on genetics as using seed native to the area	High mortality on small seed once relayed on bottom
		Irregular supply
		Biofouling of collectors
		Release of abundant particulate or soluble organic materials to the sediment below (Huang *et al.* 2019)
Buying seed from other locations (natural)		Cost associated with purchase of seed
		May impact genetic structure
		Transport issues and costs
		Irregular supply
		High mortality on small seed
		Scallops in poor health/fouled will have a low survival rate
		Can cause complications in stock assessment models (Hart *et al.* 2013)
		Potential introduction of invasive species
Reseeding – hatchery seed	Regular supply	High cost
		May impact genetic structure and diversity
		Thinner shell so higher mortality on small seed once relayed on bottom
		Seed may not be as viable as natural seed.

Table 13. Pros and cons associated with reseeding of scallops and the different methods of getting seed for scallops.

Scallop resource enhancement is receiving increasing interest as a tool to augment natural populations and stabilize or rebuild associated fisheries. While ultimately species and environment specific constraints will drive the feasibility of these efforts, examples from worldwide experiences will be helpful in guiding proposed efforts. During the meeting, David Rudders presented on a recent trip to the Hokkaido region of Japan to observe their scallop fishery. This fishery is dependent upon the collection of wild juvenile scallops and subsequent grow-out to adult size through a variety of techniques. A short video of the trip was shown and elements (biological, environmental and societal) of the Japanese fishery that were potentially translatable to other resource/regions were discussed with the WG.

A number of other presentations were also provided during the course of the meetings which are highlighted under this ToR. Summaries and main discussion points are provided below.

Latitudinal variation in *Pecten maximus* life history metrics in western UK and North East Atlantic coast fisheries

This study aimed to validate current minimum landing sizes though size at maturity analysis, assess latitudinal variations in Von Bertalanffy growth and age–weight metrics, and identify possible environmental drivers of variation using generalised linear models. Samples from Welsh grounds (Cardigan Bay, Liverpool Bay and Llyn Peninsula), Scottish grounds (Clyde, Kintyre and North West Scotland) and Irish grounds (Celtic Sea, Bertraghboy Bay, Kilkieran Bay and South Irish Sea) were collated into a single dataset. Size at maturity was calculated by both gonadal, using gonad observation inde, and morphometric, using principal component analysis, methods. Body part (shell, total, gonad, meat, exploitable and yield) weight to shell width relationships were analysed by non-linear regression and differences between areas determined by generalised linear models on log transformed data. Von Bertalanffy growth coefficients were calculated by area for both shell width and total weight data. A generalised linear model including density, latitude, sea surface temperature and chlorophyll-a concentration was constructed for each metric to determine likely environmental drivers of variation.

Scottish scallops have slower growth rates and larger maximum size than those from Welsh areas. However, Scottish scallops also reach lower maximum weights and lower weight at age, with more isometric growth than those in Welsh grounds. Sea surface temperature was the main environmental driver in variation of growth rates, along with total weight and meat weight, while sea surface temperature * chlorophyll-a interaction best explained latitudinal variation in shell weight and exploitable weight.

The findings of this study suggest that latitudinal variation, driven by differences in sea surface temperature and sea surface temperature * chlorophyll-a concentration interactions, occurs between populations, and that current minimum landing sizes are appropriate to account for that variability. Higher sea surface temperatures result in higher meat and total weights at a given shell width, along with higher shell width or total weight at a given age. Low temperatures coupled with high chlorophyll-a concentrations resulted in lower exploitable weight and shell weight, at a given shell width. While high temperatures with low chlorophyll-a concentrations result in highest exploitable weight and shell weights at a given width.

While this study was able to draw conclusions from available data, issues of differences in sampling methodology, seasonality of capture and maturation state of capture persist. It is suggested that regular sampling of fishing areas, would allow for the estimation of variation in spawn timing along the west coast of the UK and would also allow for life history metrics to be calculated for a variety of maturation states giving greater confidence to comparisons between fishing areas. The inclusion of age data for all areas would allow for the calculation of age at L_{50}; knowledge of the age at which 50% maturity is reached may have implications for the prediction of recovery rates following population crashes, or recovery rates for the establishment of closed areas. While temperature, density and chlorophyll concentration have been shown to have significant effects on life history metrics, the inclusion of sea water stratification, depth, fishing pressure, macroalgal cover and benthic habitat may reveal other patterns.

Assessment of the effects of the English channel scallop fishery on benthic habitats and species

An overview was presented to the WG of research conducted by Bangor University and the University of York which conducted a habitat assessment for Project UK: channel scallops. Project UK is a fisheries improvement programme coordinated by the Marine Stewardship Council which is aiming to improve the sustainability of a number of fisheries around the UK. This particular piece of research had three aims:

1. To assess relevant areas in relation to the effects of the channel scallop fishery on the structure and function of the habitats impacted;
2. To create a Risk Map showing habitat sensitivity that can be used to identify areas most at risk to dredging impacts;
3. To propose management measures as appropriate.

The researchers tackled this work by firstly combining species distribution models with information on fishing intensity and depletion rates to calculate the 'Relative Benthic Status' throughout the area of assessment. Most of the species examined appeared to be relatively unaffected by the fishery, although there were several areas of concern. In the second part of the work the researchers took a similar approach but this time assessed impacts at the habitat level. This produced similar results to the species based approach, but the areas of concern were slightly larger.

Although this project represented a substantial piece of work, it was constrained by limited records of key species and the absence of fishing effort data for vessels less than 12 m in length. These boats predominately work inshore where the overlap between the fishery and conservation features is likely to be highest. Addressing these knowledge / data gaps by working with the fishing industry and using the latest technology should be a priority. It was recommended that fishing effort should be concentrated to areas where there are less sensitive (longer lived) species.

Risk assessment of the effect of the UK king scallop fishery on Endangered, Threatened and Protected (ETP) species

The WG was given an overview of an MSc project done by a student from the University of York on the effect of the UK scallop fishery on Endangered, Threatened and Protected (ETP) species. The identification of ETP species interacting with UK king scallop dredge fisheries, known to inflict damage on non-target species and benthic environments, is essential for assessing the fishery's sustainability. This study, conducted as part of (and commissioned by) Project UK (see above), aimed to assess the risk of interaction between the king scallop dredge fishery operating in the North Sea, the West of Scotland and Irish Sea and any ETP species present within these regions. The objectives were to identify potential ETP species and main fishing grounds, to conduct a GIS-based risk assessment on ETP species distribution and to conduct a gap analysis.

Nineteen ETP species identified were assessed for depth and spatial overlaps (encounterability and areal overlap respectively (AO)) with the fishery, whose spatial footprint was mapped using Vessel Monitoring System (VMS) data. The attribution of risk scores allowed identification of the most-at-risk species and regions. The ocean quahog, *Arctica islandica*, burrowing sea anemone, *Arachnanthus sarsi*, were identified as most-at-risk, being ranked as high risk to both encounterability and areal overlap. While main fishing grounds indicated areas of high risk to ETP species within each region, fisheries off the West of Scotland and in the Irish Sea regions were found to pose the most risk to ETP species, achieving the highest AO risk scores. Thus, these regions are most-at-risk of failing the Marine Stewardship Council's (MSC) Fisheries Standard due to ETP species issues. Landing and bycatch data were also analysed, and multiple VMS datasets were used to allow comparison between datasets, which included >12m vessels and >15m vessels.

Although lack of data hindered the completion of a more rigorous risk assessment, this study took the first steps in assessing the fisheries' ability to become certified as sustainable by the MSC and the findings of this study are informative for further investigation into the fisheries, as part of the MSC certification process, as well as for management.

Understanding the consequences of scallop dredging on seabed habitats, conservation features and other industry sectors

The WG were given an introduction to a PhD project which aims to look at broad scale and regional issues associated with scallop dredge fisheries in the UK. The project will estimate the relative benthic status of the seafloor in the North Sea, West of Scotland, and Irish Sea ICES sub area 4 and divisions 6a and 7a as a result of exposure to scallop dredging. Where VMS data is not available the PhD aims to map the footprint of the small-scale sector and utilising alternative sources of data such as local ecological knowledge to determine (on top of existing data) the extent to which scallop fishing overlaps with different habitat types. This feeds into the Project UK Fisheries Improvement Project and should help to inform future management decisions.

Scallop fishery towed gear efficiency review paper

The WG aim to publish a review paper in a peer-reviewed journal which collates towed gear absolute catch efficiency estimates from scallop fisheries around the globe. The paper will present these estimates and discuss gear types, methods for estimating absolute catch efficiency and factors effecting absolute catch efficiency. At the 2020 meeting the proposed structure was outlined to the WG and a fresh call was made for volunteers within the WG to write sections. Many individuals volunteered and these members spanned a wide range of research institutes. Those contributing were asked to complete their sections by the end of December 2020.

How many sea scallop are there and why does it matter?

The Atlantic sea scallop (*Placopecten magellanicus*) supports valuable Canadian and US fisheries in the western North Atlantic, an area projected to experience ocean acidification and increased seawater temperatures due to global climate change. This study focuses on the effects of climate change, oceanic conditions along the Atlantic Coast of North America that are changing, as well as surface water temperatures in the Gulf of Maine, which have increased faster than 99% of the global oceans. Given that this bivalve mollusc is characteristically sensitive to changing physical conditions, establishing a baseline of scallop abundance will be important to help track regional environmental variability over time. The research examines the role of the sea scallop as a baseline sentinel species that can be used to measure the impacts of environmental change and anthropogenic developments. Further information can be found;

https://esajournals.onlinelibrary.wiley.com/doi/full/10.1002/fee.2244

2.7 ToR g) Compare age reading methodologies and attempt to develop common practices and determine precision and bias of scallop age reading data derived from different readers

Last year WGScallop drafted a resolution to host a workshop on scallop aging (WKSA) and this took place in March 2020 (prior to Covid Lockdown). The workshop was well supported with contributions from 21 attendees representing 10 institutes. The following ToRs were addressed:

a) Review and compare current scallop age reading methodologies (including quality assurance) and agree on best practice ;
b) Develop, agree and write a standard procedure for use in future scallop exchanges;
c) Assess the potential use of SmartDots for king scallops;
d) Start a reference collection of scallop shells with a consensual age;
e) Discuss the benefits of future exchanges or workshops.

Each institute presented a description of their current aging method for the report. It was agreed that different areas required different approaches to the aging method itself, but there should be agreed aims that the processes should fulfil. SmartDots was demonstrated and attendees had an opportunity to evaluate it. It was generally agreed that it may be useful, particularly for training. The WG proposed that a reference collection should be collated for each fishery area. An exercise in which attendees individually aged a set of scallop shells showed significant disparity. This was reduced when working in groups to reach a consensus age. Future workshops would be beneficial and the WG proposed a second workshop in October 2021.

MSS scallop image based age reading trial

At the end of 2019, MSS started a project looking at an image based age reading for scallops. MSS trialled several imaging techniques before settling on a simple and replicable set up and taking images of 22 scallop shells, to be read by samplers. The details of the initial phase of the project can be found in the WKSA report (https://www.ices.dk/community/groups/Pages/WKSA.aspx).

The scallop image based age reading trial has been progressing slowly. There are 15 readers involved who have read the scallops virtually from images, but with COVID-19 we are still awaiting the real scallop age readings. Based on the results so far we can see that it is possible to read the scallops from images, with experts showing relatively high percentage agreement of ~60% (Table 14).

modalAge	all	all_EXP	all_INT	all_BEG
4	20	60	0	0
5	47	60	50	25
6	48	60	50	31
7	33	52	23	25
8	37	48	30	35
9	37	80	17	12
totals	**38**	**60**	**30**	**26**

Table 14. The percentage agreement results split by All readers, Experts, Intermediates and Beginners.

Using the age bias plots it is possible to determine training needs for readers. Readers were asked to classify themselves as experts, intermediates or beginners, and the plots reveal if readers are reading appropriately compared to others in their experience group. For example we can see that R1 who classed themselves as an expert appears to be over-estimating the age readings compared to the other experts (Figure 32). This may suggest that R1 needs further training.

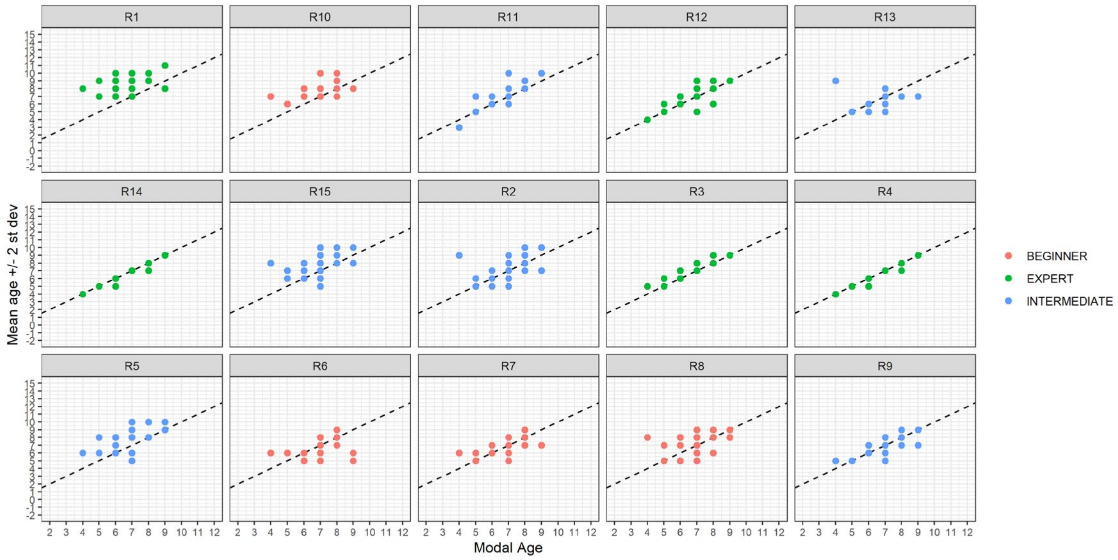

Figure 32. Age bias plots of each individual reader and their experience level Beginner (red), Intermediate (blue), Expert (green).

The next stage is to have all 15 readers age the scallop shells in real life and compare the results to determine how similarly they are able to read the real scallops and scallop images. In future it is hoped that SmartDots could be used for the imaging assessment as a training database for scallop readers as well as a potential quality control measure. A new selection of scallops will be collected and imaged by the end of 2020 to increase the dataset. An update will be given on the project at the next meeting and aging workshop in 2021.

Annex 1: List of participants

Member	Dept/Institute	Country	Email
Lynda Blackadder	Marine Science Scotland	Scotland, UK	lynda.blackadder@gov.scot
Adam Delargy	Bangor University	Wales, UK	adam.delargy@bangor.ac.uk
Andy Lawler	Centre for Environment, Fisheries and Aquaculture Science	England, UK	andy.lawler@cefas.co.uk
Bryce Stewart	University of York	England, UK	bryce.beukers-stewart@york.ac.uk
Carrie McMinn	Agri-food and Biosciences Institute	Northern Ireland, UK	Carrie.McMinn@afbini.gov.uk
Claire Lambden	Orkney Sustainable Fisheries	Scotland, UK	c.lambden@orkneysustainablefisheries.co.uk
Claire Szostek	Bangor University	Wales, UK	c.szostek@bangor.ac.uk
Dave Rudders	Virginia Institute of Marine Science	United States	rudders@vims.edu
David Palmer	Cefas	England, UK	dave.palmer@cefas.co.uk
Ellen Sofie Grefsrud	Institute of Marine Research	Norway	ellen.sofie.grefsrud@hi.no
Eric Foucher	Ifremer	France	eric.foucher@ifremer.fr
Fabian Zimmermann	Institute of Marine Research	Norway	fabian.zimmermann@hi.no
Francis Binney	Government of Jersey	Channel Islands, UK	F.Binney@gov.je
Helen Dobby	Marine Laboratory	Scotland, UK	h.dobby@marlab.ac.uk
Isobel Bloor	University of Plymouth	Isle of Man	i.bloor@bangor.ac.uk
Jónas Jónasson	Marine and Freshwater Research Institute	Iceland	jonas.jonasson@hafogvatn.is
Kevin Stokesbury	University of Massachusetts Dartmouth	United States	kstokesbury@umassd.edu
Mairi Fenton	Heriot Watt	Scotland, UK	mmf13@hw.ac.uk
Matthew Coleman	Orkney Sustainable Fisheries	Scotland, UK	matt@orkneysustainablefisheries.co.uk
Michael Sheridan	Marine Institute	Ireland	mikecsheridan@gmail.com
Nikolai Nawri	Cefas	England, UK	nikolai.nawri@cefas.co.uk
Oliver Tully	Marine Institute	Ireland	oliver.tully@marine.ie
Paul Chambers	Government of Jersey	Channel Islands, UK	P.Chambers@gov.je

Pia Schuchert	Agri-food and Biosciences Institute	Northern Ireland, UK	pia.schuchert@afbini.gov.uk
Samantha Stott	Cefas	England, UK	samantha.stott@cefas.co.uk
Shona Kinnear	Marine Science Scotland	Scotland, UK	shona.kinnear@gov.scot
Spyros Fifas	Ifremer	France	spyros.fifas@ifremer.fr

Annex 2: WGScallop resolution

The **Scallop Assessment Working Group** (WGScallop), chaired by Lynda Blackadder, Scotland, UK, will work on ToRs and generate deliverables as listed in the Table below.

	Meeting dates	Venue	Reporting details	Comments (change in Chair, etc.)
Year 2019	7–11 October	Isle of Man		
Year 2020	5–9 October	by corresp/ webex		physical meeting cancelled - remote work
Year 2021			Final report by Date to SCICOM	

ToR descriptors

ToR	Description	Background	Science plan codes	Duration	Expected Deliverables
a	Compile and present data on scallop fisheries in ICES areas II, IV, V, VI and VII by collating available fishery statistics.	The fisheries are socio-economically important and there is a need to collate these data at a national level to ensure assessments can proceed.	5.1	Years 1,2,3	Landings, effort and commercial sampling data on listed species, from each country.
b	Review recent/current stock assessment methods of the main scallop species and explore other methodologies; including comparisons with fishery dependent indicators.	The aim is to assess the status of scallop stocks and contribute to Integrated Ecosystem Assessment and Management and descriptor 3 of the MSFD.	5.1, 6.3	Years 1,2,3	Report on alternative assessment methods. Link with WKLIFE.
c	Collate all available data and attempt to conduct a stock assessment for the north east Irish Sea.	The Isle of Man currently conducts stock assessments on their territorial seas. The aim is to assess the wider area.	5.1, 6.2	Years 1,2,3	Stock assessment for north east Irish Sea.
d	Review and report on current scallop surveys and share expertise, knowledge and technical advances.	Focus will be on reporting recent updates with regards to surveys and sampling, use of cameras, gear efficiency and selectivity, impact of scallop dredging, discard mortality, MPA's and closed areas, bycatch.	1.4, 1.5, 4.4, 5.2, 5.4	Years 1,2,3	WG report chapters. Exchange of scientific staff on surveys. Database to collate bycatch data.

e	Continue to refine stock structure using best available information on genetics and larval dispersal and look to improve current mapping of scallop stocks.	Knowledge on the genetic stock structure and extent of larval dispersal is still weak but a number of projects are underway.	1.4, 1.8	Years 1,2,3	WG report chapters and relevant maps. Link with WGSFD.
f	Keep current biological parameters under review and update when more information becomes available and report on all relevant aspects of: biology, ecology, physiology and behaviour, in field and laboratory studies.	Several biological parameters are important for analytical assessments and parameters may vary depending on the stock area.	5.1, 5.2	Years 1,2,3	Update knowledge on crucial stock parameters.
g	Compare age reading methodologies and attempt to develop common practices and determine precision and bias of scallop age reading data derived from different readers and methods.	Many institutes rely heavily on aging methods but there are no common methodologies or protocols.	4.4, 5.1	Years 1,2,3	Produce guidelines on agreed methodologies.

Summary of the Work Plan

Year 1	Annual standard outputs for ToR a,d,e, f. Collate lists of available data for Irish Sea (c). Age reading workshop (g), arrange scientific staff exchange on surveys (d) and knowledge exchange on current scallop stock assessment methods (b).
Year 2	Annual standard outputs for ToR a,d, f. Collate available data for Irish Sea (c). Age reading guidelines further discussed (g). Update and report on genetic and larval dispersal models and attempt to colloborate on further work (e). Review scallop stock assessments caried out by national institutess (b).
Year 3	Annual standard outputs for ToR a,d, f. Stock assessmnet for Irish Sea (c). Age reading guidelines produced (g). Produce maps on genetic stock structure and larval dispersal (e) Further develop scallop stock assessment methods (b).

Supporting information

Priority	The fisheries for scallops are socio-economically important and trans-national in Europe and North America. Management of stocks in Europe is primarily by technical measures and in most countries there are generally little or no management instruments to control fishing effort. This is currently the only scientific assessment forum for discussion and development of common assessment methods for scallops. Consequently, these activities are considered to have a very high priority.

Resource requirements	The research programmes, which provide the main input to this group, are already underway, and resources are already committed. The additional resource required to undertake additional activities in the framework of this group is negligible.
Participants	The Group is normally attended by 16 members and guests.
Secretariat facilities	None
Financial	No financial implications.
Linkages to ACOM and groups under ACOM	There are no obvious direct linkages as the WG does not currently provide advice.
Linkages to other committees or groups	There are currently no direct linkages but the WG has made recommendations for WGSFD and WKLIFE.
Linkages to other organizations	None

Annex 3: Data tables

Year	33E2	33E3	33E4	33E5	34E3	34E4	34E5	35E3	35E4	35E5	35E6	36E3
2000	16.5	92.2	396.1	298.5	0	58.7	37.8	33.8	34	111.4	43	27.9
2001	4.5	90.9	248.3	126.6	1.1	31.5	2.5	15.8	30.2	83.3	109.2	31.9
2002	0	40.5	133.4	102.6	0	51.1	1	2	3.2	111	58.1	3
2003	18.6	89	90.3	250.8	0	16.3	1.6	5.2	5.3	25.6	66.2	23
2004	24.1	160.8	154.1	645.4	8	15.4	45.3	4.3	0.9	61.3	24.4	5.3
2005	23.6	178.3	13.2	319.8	0	0.2	4.4	0	0	87.2	49.1	7.6
2006	44.2	333.6	54.9	446.9	0	0.3	24	3.2	0.3	22.4	6.9	0
2007	17.5	335.4	159.9	1167.4	4	1.7	89.4	6.1	1.9	95	11.2	7.4
2008	42.6	238.2	220.1	3961.9	0	25.4	215.4	0	0.1	111.8	3.3	8.6
2009	47.4	95.4	180.1	2309.5	8	0	249.8	0	1	116.7	217.6	2.8
2010	6.4	135.7	84.2	2014.2	0.5	5.3	353.6	0	0.5	223	48.7	11.3
2011	31.8	325.3	67.3	2613.1	4.5	3.9	365.2	0.9	91.1	245.8	67.3	37.9
2012	47.9	480.4	59.3	3392.5	0	0.7	258.1	2.7	4.6	189.5	59.6	26
2013	140.8	475.6	49.2	1388.2	0	9.6	627.5	4.2	8	238.2	20.6	5
2014	67.1	605.5	118.2	1041.5	4.1	26.7	401.6	3.5	101.2	96.5	18.3	7.1
2015	9.1	237.2	63.3	387.6	11.1	22.6	119.9	9	75.9	76.5	58.1	28.2
2016	33.2	114.1	146.8	178.2	9.3	38.2	223	36.4	137.6	65	58.2	15.9
2017	59	92.3	21.3	184.3	3.7	10.9	105.6	0	105.8	82.4	15	0.1
2018	45.2	76.5	30.8	292.3	2.5	0.2	137.2	3.9	77	115	139.3	1.3
2019	3.2	205.3	22.7	451	3.6	11.8	113.4	0	35.6	78.9	103.7	1.5

Year	36E4	36E5	36E6	36E7	37E3	37E4	37E5	37E6	37E7	38E4	38E5	38E6
2000	17.1	100.7	268.4	0	0	104.7	167.5	6	0	176	31	5.7
2001	40.8	219.4	287.3	0	4.7	191.5	269.3	0.5	0	165.5	2.6	0
2002	22.4	369.5	225.6	0	0	138.3	556.6	30.6	0	183.9	105.1	14.3
2003	21.7	604.1	139.8	0	0	97.4	530.6	3.3	0	195.5	144.3	3.6
2004	31.9	425.8	89.7	0	4.4	239	283.2	16.5	0	198.7	347.5	30
2005	15.9	363.6	46.9	0	9.7	165.4	715.2	10.1	0	119.1	231	36.9
2006	22.2	304.7	46.8	2	0	119.8	631.2	5	0	150.1	167.2	2.1
2007	33.4	420	186.9	0	0.2	248.4	878.3	12.1	1.7	97.1	206.2	11.9
2008	63.4	820.3	96.9	0.1	0	288	658.5	52.1	0	155.1	246.3	14.3
2009	39.1	950.4	278.1	0	0.4	224.5	1489.6	64	0	147.8	237.6	3.3
2010	14.9	1561.6	98.5	0	3.5	186.8	1369.7	130.8	3.4	123	197.6	3.1
2011	65.5	1341.6	99.1	1.7	1.8	221.6	2301.6	53.4	0	207.7	179.1	1.9
2012	63.6	1392.2	205.7	3.6	0	263.7	2562.6	57	1.5	133.3	392.5	19.1
2013	79.1	1819.6	147.2	0	5.2	230.3	2485.7	45.1	0	374.9	214.9	5.1
2014	74.4	1739.4	156	0.9	1.6	275.2	2677.1	33.5	0	376.2	285	2.1
2015	43.7	1513.8	214.7	0.1	4.7	371.2	2940.5	32.2	0.1	416	212.7	16.1
2016	109.8	2293.9	195.2	0	19.1	258.1	3571	7.6	0	393.8	319	2.9
2017	73.6	1378.7	154.3	0	0	293.2	2250.9	13.9	0	462.5	247.2	2.1
2018	77.8	1508.8	209.6	0	0	190.4	1901.5	6.5	0	357	192.1	3.8
2019	35.4	789.7	182	0	0.9	259.3	1516.2	5.9	0	228.5	204.6	0.5

Table A1. Total landings (live weight, t) of king scallops by year and ICES statistical rectangle from ICES sub area VIIa (Irish Sea).

Assessment Area	Year	Belgium	France	Ireland	Isle of Man	Netherlands	Channel Islands	UK	Total International
27.4.b.S	2000	0	0	0	0	0	0	108	108
	2001	0	0	0	0	0	0	775	775
	2002	0	0	0	0	0	0	1068	1068
	2003	0	0	0	0	0	0	554	554
	2004	0	0	0	0	0	0	103	103
	2005	0	0	0	0	0	0	282	282
	2006	1	0	0	0	0	0	259	260
	2007	2	0	0	0	0	0	285	287
	2008	0	0	0	0	0	0	370	370
	2009	0	0	0	0	0	0	394	394
	2010	0	0	0	0	0	0	360	360
	2011	0	0	0	0	0	0	699	699
	2012	0	0	0	0	0	0	990	990
	2013	0	0	0	1	0	0	352	353
	2014	0	0	0	0	0	0	2286	2286
	2015	0	0	0	0	0	0	3188	3188
	2016	0	0	0	0	0	0	1053	1053
	2017	9	0	0	0	0	0	2503	2512
	2018	0	0	0	0	0	0	2322	2322
	2019	0	0	0	0	0	0	2333	2333
27.7.d.N	2000	0	2605	0	0	0	0	1599	4204
	2001	0	3385	0	0	88	0	973	4446
	2002	0	4977	0	0	126	0	1310	6413
	2003	0	4824	207	0	190	0	1822	7043
	2004	0	4750	311	0	222	0	1394	6677
	2005	0	4416	36	0	162	0	1232	5846
	2006	395	4356	0	0	289	0	1561	6601
	2007	397	6124	0	0	154	0	2410	9085
	2008	376	5772	0	0	277	0	1826	8251
	2009	536	6107	0	0	299	0	5911	12853
	2010	530	6690	0	0	148	0	9509	16877
	2011	345	6796	5	0	0	0	8083	15229
	2012	202	5711	0	0	0	0	3061	8974
	2013	274	8327	14	0	0	0	3179	11794
	2014	576	4217	232	0	0	0	4154	9179
	2015	354	2998	7	0	0	0	1602	4961
	2016	358	4263	86	0	0	0	1896	6603
	2017	325	3952	228	0	0	0	3429	7934
	2018	277	7240	781	0	0	0	6160	14458
	2019	205	4260	596	1	0	0	6386	11448
27.7.e.I	2000	0	0	54	0	0	0	3674	3728
	2001	0	0	60	0	6	0	2523	2589
	2002	0	0	58	0	45	0	2046	2149
	2003	0	0	285	0	107	0	2380	2772

	2004	0	2	578	0	64	0	2901	3545
	2005	0	1	277	0	224	0	3331	3833
	2006	3	1	4	0	37	0	3286	3331
	2007	14	0	10	0	139	0	1557	1720
	2008	16	2	1	0	121	0	1357	1497
	2009	8	33	0	0	185	0	2281	2507
	2010	13	38	0	0	107	0	1053	1211
	2011	9	50	46	0	0	0	1869	1974
	2012	74	1	2	0	0	0	2554	2631
	2013	13	1	1	0	0	0	2508	2523
	2014	137	0	4	0	0	0	1709	1850
	2015	132	0	33	0	0	0	3823	3988
	2016	103	0	28	1	0	0	2878	3010
	2017	23	0	5	0	0	0	2397	2425
	2018	64	0	1	0	0	3	1809	1877
	2019	21	5	0	0	0	0	2054	2080
27.7.e.L	2000	0	1	0	0	0	0	2790	2791
	2001	0	16	0	0	54	0	1475	1545
	2002	0	2	0	0	0	0	1468	1470
	2003	0	6	2	0	0	0	973	981
	2004	0	16	8	0	2	0	1775	1801
	2005	0	17	16	0	67	0	2788	2888
	2006	2	3	0	0	2	0	2286	2293
	2007	8	30	0	0	1	0	2011	2050
	2008	2	17	0	0	0	0	1738	1757
	2009	3	36	0	0	46	0	1823	1908
	2010	3	22	0	0	16	0	2633	2674
	2011	19	41	0	0	0	0	3807	3867
	2012	10	3	0	0	0	0	3029	3042
	2013	4	7	0	0	0	0	2407	2418
	2014	24	0	0	0	0	0	1896	1920
	2015	10	1	0	4	0	0	1367	1382
	2016	5	0	0	2	0	0	1562	1569
	2017	8	0	0	0	0	0	1704	1712
	2018	9	1	0	0	0	0	1908	1918
	2019	6	2	0	0	0	2	1691	1701
27.7.e.O	2000	0	1270	0	0	0	0	554	1824
	2001	0	944	0	0	32	0	578	1554
	2002	0	775	0	0	1	0	720	1496
	2003	0	880	1	0	0	0	1139	2020
	2004	0	965	0	0	0	0	700	1665
	2005	0	617	0	0	0	0	381	998
	2006	15	558	0	0	0	0	559	1132
	2007	42	1430	0	0	50	0	2407	3929
	2008	43	1251	0	0	16	40	1569	2919
	2009	121	788	0	0	66	0	2054	3029

	2010	114	783	0	0	0	1	3140	4038
	2011	33	638	0	1	0	0	1637	2309
	2012	173	611	0	0	0	0	2662	3446
	2013	16	1008	2	0	0	85	2948	4059
	2014	104	1168	1	0	0	67	1285	2625
	2015	47	654	3	0	0	57	999	1760
	2016	58	751	0	1	0	45	846	1701
	2017	6	264	0	0	0	56	573	899
	2018	15	193	0	0	0	215	1179	1602
	2019	9	163	0	0	0	417	1128	1717
27.7.f.I	2000	0	0	76	0	0	0	43	119
	2001	0	0	36	0	0	0	24	60
	2002	0	0	3	0	0	0	20	23
	2003	0	0	82	0	0	0	52	134
	2004	0	0	5	0	0	0	17	22
	2005	0	0	7	0	0	0	40	47
	2006	56	0	0	0	110	0	147	313
	2007	92	0	4	0	5	0	29	130
	2008	57	0	0	0	5	0	64	126
	2009	40	0	0	0	0	0	203	243
	2010	59	0	31	0	0	0	544	634
	2011	80	0	143	0	0	0	141	364
	2012	120	0	15	0	0	0	161	296
	2013	134	0	47	0	0	0	393	574
	2014	137	0	21	0	0	0	162	320
	2015	79	0	0	0	0	0	37	116
	2016	61	0	81	0	0	0	109	251
	2017	45	0	5	0	0	0	310	360
	2018	55	0	2	0	0	0	86	143
	2019	51	0	0	0	0	0	221	272

Table A2. Provisional landings of king scallop 2000–2019 by Assessment Area and country, as provided to WGScallop. See issues in table A1.