SCALLOP ASSESSMENT WORKING GROUP(WGSCALLOP; Outputs from 2022 meeting)

VOLUME 5 | ISSUE 08

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 5 | Issue 08

SCALLOP ASSESSMENT WORKING GROUP(WGSCALLOP; Outputs from 2022 meeting)

Recommended format for purpose of citation:

ICES. 2023. Scallop Assessment Working Group(WGScallop; Outputs from 2022 meeting). ICES Scientific Reports. 5:08. 75 pp. https://doi.org/10.17895/ices.pub.22189654

Editors

Lynda Blackadder

Authors

Rhei Ammaturo • Samantha Bampleid • Francis Binney • Lynda Blackadder • Isobel Bloor
Simone D'Alessandro • Adam Delargy • Helen Dobby • Mairi Fenton • Spyros Fifas • Eric Foucher
Ellen Grefsrud • Jessica Harvey • Natalie Hold • Jónas Jónasson • Shona Kinnear • Andy Lawler
Guillermo Martin • Carrie McMinn • David Murray • Nikolai Nawri • Dave Rudders • Tiago Silva
Bryce Stewart • Kevin Stokesbury • Claire Szostek • Oliver Tully • Karen Vanstaen
Fabian Zimmermann

ICES CIEM 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 scallop surveys, stock assessment methodologies, advances in technology, scallop aging procedures, and recent studies on scallop species to develop and improve stock assessment methods.

The group welcomed four new members this year and spent time discussing diversity and inclusion to ensure that we are doing everything possible to make this working group accessible and welcoming. This WG will continue to work with ICES to ensure that progress continues, and we are very pleased that we have several PhD students who participated in the meeting.

Several group members contributed to the review paper, "A global review of catch efficiencies of towed fishing gears targeting scallops" being published in "Reviews in Fisheries Science and Aquaculture". This paper provides an in-depth review and discussion of the factors which influence catch efficiency, relating the considerable variation in the catch efficiency estimates (0.1 to 0.7) to scallop size and substrate type as the two most important factors.

Work on progressing a stock assessment for the Irish Sea included five intersessional subgroup meetings which involved members of the Working Group on Operational Oceanographic products for Fisheries and Environment (WGOOFE). Members of WGScallop have been using available Vessel Monitoring Systems (VMS) data and logbooks to consider various models (Vector Autoregressive Spatial-Temporal Model (VAST) and SPict) and standardized survey indices. A stock annex has been drafted for king scallops in the Irish Sea.

Surveys continue to be integral for many of the institutes and the WG discussed the possibility of staff exchanges between surveys and have also agreed to hold an intersessional meeting to discuss survey design and related common issues.

This was the third year of submitting a data call and there continues to be issues with the data quality. ICES Secretariat presented an overview of the Regional Database Estimation System (RDBES) and the group have agreed to use this framework. There will be a period of overlap and intersessional work will include a comparison between the datasets (WGScallop data call and RDBES).

Work continues on scallop stock connectivity, larval dispersal and genetics, and the WG were given a presentation from the Stock Identification Methods Working Group (SIMWG). The WG will continue to discuss options for mapping of VMS data and aim to draft a paper which will address the issues previously reported. The WG continues to work alongside the Workshop on Scallop Aging (WKSA) and are pleased that a workshop will be held in 2023.

The WG discussed the ToR, identified leads for each and agreed to further discuss the two interrelated ToR (B and C) considering options for combining work areas.

ii Expert group information

Expert group name	Scallop Assessment Working Group (WGScallop)
Expert group cycle	Multiannual fixed term
Year cycle started	2022
Reporting year in cycle	1/3
Chair	Lynda Blackadder, Scotland, UK.
Meeting venue and dates	4-6 October 2022, Hafnarfjordur, Iceland, (29 participants; 22 online and 7 in person)

Terms of Reference (ToR)

a) Compile and present data on scallop fisheries in ICES areas II, IV, V, VI and VII by collating available fishery statistics.

b) Review recent/current stock assessment methods of the main scallop species and explore other methodologies; including comparisons with fishery-dependent indicators and potential utilisation of oceanographic data within the assessment process.

c) Conduct a stock assessment for the northeast Irish Sea and work with WGOOFE to include environmental variables where appropriate.

d) Review and report on current scallop surveys and share expertise, knowledge, and technical advances. Review electronic monitoring (EM) for scallop fisheries.

e) Continue to refine stock structure using best available information on genetics and larval dispersal and improve current mapping of scallop stocks. Establish links with WGOOFE to collaborate on specific work areas.

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

g) Compare age reading methodologies and develop common practices and determine precision any bias of scallop age reading data derived from different readers.

h) Identify, list, and collate all available data for queen scallops and agree on appropriate stock assessment areas. Share knowledge, draft a review paper, and attempt stock assessments where possible.

Summary of work plan

Year 1	Linked to ToR; a) Refine data call, highlight and address issues. b) Continue to explore index standardization and stock assessment methodologies including surplus production model for scallop stocks (and establish closer links with other assessment WGs (WGNSSK)) c) Apply a SPiCT model for the Isle of Man, using survey and CPUE (VMS/logbook) indices standardized with VAST. Continue to explore other alternative models and establish communications with WGOOFE. d) Continue to report and share knowledge of surveys and plan for scientific staff exchanges. f) Dredge efficiency review paper h) Form subgroup for queen scallop work Establish links with WGNSSK, WGSFD and WGOOFE with regular communications
Year 2	Linked to ToR; a) Data call - streamline and document checking process (upload scripts to GitHub) b) Review scallop ICES stock categories and discuss possible reference points (following ICES guidelines from WKREF2) c) Incorporate other spatial areas and environmental variables from the Irish Sea (collaborative work with WGOOFE) d) Undertake scientific staff exchanges on scallop surveys. g) TIMES document on aging methodologies in collaboration with WKSA

Year 3	Linked to ToR; a) Data call – need to consider long term storage options (central database/RDB) b) Set up a more formal checking and review process for stock assessments c) Produce Viewpoint and Management Strategy Evaluation of Irish Sea scallops. d) Report on electronic monitoring (EM) for scallop fisheries and collaborate with WGSFD to produce mapping products. h) Queen scallop review paper

The ToR covered a three-year work plan period (2022–2024). Every year the WG reports on current scallop work and shares expertise, knowledge, and technical advances and a WG report is produced.

This is our first year of a new cycle and significant work has been done on ToR a, and we are now ahead of schedule for the data call. Checking scripts have been improved, streamlined and uploaded to GitHub and the group have discussed the benefits of the Regional Database Estimation System (RDBES) and will now progress to using these data call and database, although work is required to compare the two datasets.

Work continues on developing different scallop stock assessment methods, with considerable progress on ToR c (Irish Sea) and members considering various options for potential survey indices, while successfully collaborating with the Working Group on Operational Oceanographic products for Fisheries and Environment (WGOOFE).

The plans for staff exchanges were disrupted by the Covid-19 pandemic, but members agree this is something that would still be of benefit and potential survey dates and options will be discussed for 2023. A new subgroup will also discuss common issues or problems encountered on surveys.

The WG are pleased with the progress that has been made with PhD projects focusing on larval dispersal and stock connectivity and considered options for working with the Stock Method Identification.

A catch efficiency paper, "A global review of catch efficiencies of towed fishing gears targeting scallops" has been published by multiple members of the WG in Reviews in Fisheries Science and Aquaculture (A Global Review of Catch Efficiencies of Towed Fishing Gears Targeting Scallops).

1 ToR A Compile and present data on scallop fisheries in ICES Subareas 2, 4, 5, 6 and 7 by collating available fishery statistics.

Prior to 2020, the WG had only limited access to scallop landings and effort data through the ICES Regional Database (RDB). A subgroup evaluation noted data missing from countries with known scallop fisheries and inconsistencies in the landings when compared to national in-house data sources. The WG agreed a data call was required and ICES issued this in August 2020, January 2021, and February 2022; requesting landings and effort data for scallop species in ICES areas 2, 4, 5, 6, 7 and 8. The ICES Fisheries Data call 2022 can be seen here: https://doi.org/10.17895/ices.pub.10038.

WG members were asked to check the collated data and highlight any problems (Table 1). There was not time to discuss these fully at this year's meeting (as the number of days were reduced to three). England submitted data on behalf of England and Wales and data for the Isle of Man were made available during the WG meeting.

Table 1. Issues identified with the 2022 WGScallop data call and steps taken to rectify them.

Country	Issue(s)	Solution(s)	Implication(s)
Isle of Man	Data missing	Provided during meeting	Plots and tables reproduced
France	Large number of métiers reported	Removed during data cleaning process	Modified scripts
Belgium	Very high effort reported for TBB_DEF métier		

ICES provided a presentation on the RDB Regional Database Estimation System (RDBES) to the WG and the group discussed the option of moving to using the "All species" RDB data call. The hope is that this may help to improve the quality of the fisheries data but would also provide benefits because of the finer scale resolution of the data available (possibly down to each trip and haul level, compared to aggregated monthly data by ICES statistical rectangle). The WG agreed that the data call would continue, and that we would also complete inter sessional work to compare data to the RDBES data. The aim would be to have a period of overlap, with the intention of fully moving to using data from the RDBES database in future. It is hoped that moving to these data call source may improve the data quality and that the Governance group may also be able to facilitate the discussions regarding scripts and protocols for data extractions and aggregations at the national institutes.

King scallops dominate the landings and collation of preliminary king scallop landings show the majority are from ICES Subarea VII (Table 2). Total landings have increased steadily over the period from 2000 to 2012 to approximately 64 000 tonnes landed for the subareas reported (Figure 1). Landings fell slightly between 2014 and 2020 but have been increasing again and were reported as approximately 71 792 tonnes in 2021, which is the highest for the time-series. Further plots of landings and effort are available in Annex 3.

Table 2 Provisional landings (live weight (including shell), tonnes) of king scallops for 2000 –2022 by ICES Subarea as submitted through the ICES data call. Data for the Isle of Man are not available prior to 2011 and data for Scotland are not available prior to 2002.

ICES Subarea								
Year	**I**	**II**	**IV**	**V**	**VI**	**VII**	**VIII**	**Total**
2000	0	0	147.9	0	122.5	23964.1	783.2	25017.7
2001	0	0	814.8	0	79.5	26965.4	1048.5	28908.2
2002	0	0	3174.9	0	6651.1	32104.6	788.7	42719.3
2003	0	0	4222.3	0	5968	32866.9	973.3	44030.5
2004	0	0	5674.5	0	5145.5	40618.7	902.9	52341.6
2005	0	666.5	4916.3	0	4409.7	44238.9	1038.4	55269.8
2006	0	788	4889.9	0	3392.7	41710.6	1189.3	51970.5
2007	1.2	864.1	5458.2	0	3028.3	42888.6	1340.6	53581
2008	0	896.7	4805.4	0	3909.4	45841.5	1288.7	56741.7
2009	0	742.8	5361.4	0	3545.7	44982	906.1	55538
2010	0	748.5	4829.2	0	3438.8	51334.3	479.4	60830.2
2011	0	715.3	3800.8	0	3503	53267.7	260.7	61547.5
2012	0	664.3	5532.2	0	5300	52219.2	874.6	64590.3
2013	0	678.4	7596.5	0	4536.7	49769.1	826.7	63407.4
2014	0	747.8	7072.5	0	5306.7	41465.4	348.2	54940.6
2015	0	555.7	9027.8	0	4357.1	39803.9	496.6	54241.1
2016	0	545.6	7706.9	1.6	4737.4	43802.5	677.2	57471.2
2017	1.3	486.6	7669	0	3569.3	46145.7	716.2	58588.1
2018	0	559.2	6249.4	0	2938	50794	718	61258.6
2019	0	447.9	5642	0	2900.8	52402.1	617.1	62009.9
2020	0	0	6469.3	0	2165.6	48121.5	678.4	57434.8
2021	0	1.5	7274.2	0	2309	61919.2	288.6	71792.5

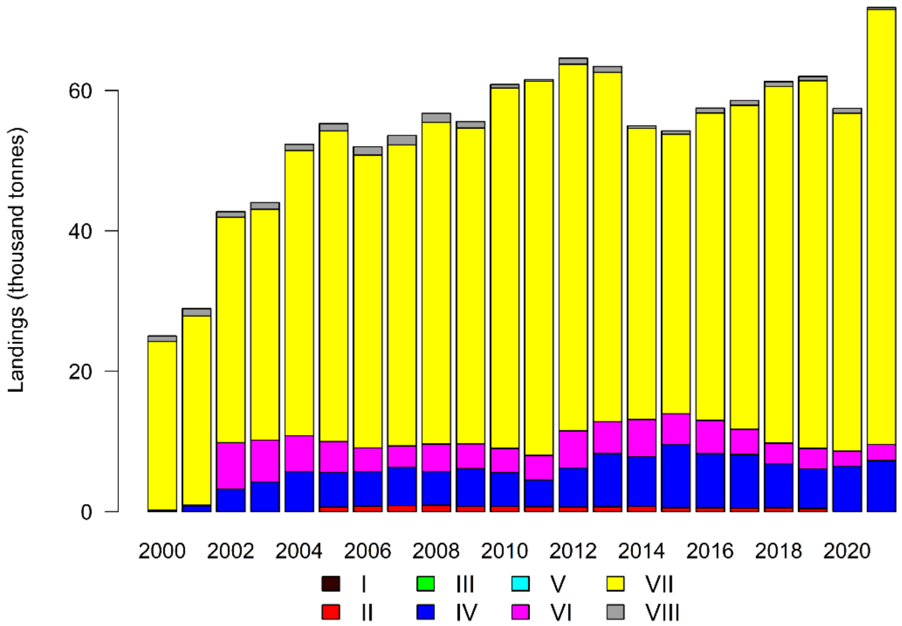


Figure 1 Annual landings (live weight (including shell), thousand tonnes) of king scallops from 2000 –2021. Landings are divided by ICES Subarea within each year, as coloured by the legend. Data for Isle of Man are not included prior to 2011 and Scotland are not included prior to 2002.

2 ToR B Review recent/current stock assessment methods of the main scallop species and explore other methodologies; including comparisons with fishery-dependent indicators and potential utilisation of oceanographic data within the assessment process.

Stock assessment methods will be kept under review and the group continue to provide feedback on work undertaken by each institute. This ToR also overlaps with work conducted as part of ToR C and D and relevant updates are provided below. Many stock assessments rely on surveys and the group consensus was that relevant information and data sources should be reported together for each assessment area.

3 ToR C Conduct a stock assessment for the northeast Irish Sea and work with WGOOFE to include environmental variables where appropriate.

Subgroup meetings took place during Q1 of 2022 but were then put on temporary hold due to limits on the availability of subgroup members. Meetings occurred in January and March 2022 and progress was made on developing standardized abundance indices for both the Isle of Man and Irish king scallop fleets (separately) using VAST. Discussions of refining these indices included the need to incorporate missing fleet data (i.e. Scottish, Welsh, and Northern Irish vessels), the availability of which is being explored, and environmental and oceanographic variables. The subgroup meetings were also attended by members of WGOOFE with a view to developing a collaborative relationship for incorporating oceanographic datasets (i.e. bed sheer stress, chlorophyll-a, and more) to improve modelling and refine scallop abundance indices and assessments. The group have also progressed a draft stock annex report and have discussed the potential for progressing a Management Strategy Evaluation for scallops. The subgroup will continue to meet regularly in Year 2 (2022/2023) to progress the objectives of this ToR.

The WG has started exploring the use of VMS and logbook data from the northeast Celtic Sea. VMS data provides georeferenced positions at, generally, two-hour intervals for every EU vessel above 12 meters in length. Additionally, VMS data includes vessel speed and bearing angle. The Celtic Sea was chosen as a case study for two reasons; 1) only Irish scallop dredgers operate in the area and 2) the number of Irish scallop vessels fishing in the area ranges between six and nine, which facilitates data management and analysis and reduces the need for data integration across countries at this stage.

Having access to VMS and logbook data potentially enables a range of research , including developing indices of abundance (Murray *et al*., 2013), fishing aggregation studies (Hintzen *et al*., 2019) or swept-area ratio estimation (Gerritsen *et al*., 2013). Additionally, the WG, in collaboration with members of WGOOFE, is exploring the possibility of linking scallop VMS and logbook data with environmental layers such as multibeam acoustic backscatter of the seafloor, which is a proxy for sediment or habitat type, or oceanographic variables such as temperature and chlorophyll to understand potential environmental drivers of scallop productivity that could aid in future modelling.

The vmstools' framework provides guidelines for the processing and analysis of VMS data and linking with logbook data. Processing steps include the delimitation of the area of interest, subsetting to the Irish scallop fleet, removal of duplicated pings and those on land and close to harbour, and classifying fishing and non-fishing activity. Fishing pings were identified based on speed thresholds. After the visualisation of speed profiles, fishing activity was defined at between 0.8 –4 knots. Landings from logbook data were split across fishing pings for each vessel based on the trip reference number and fishing date.

After processing the VMS scallop data, it was clear that fishing patterns were aggregated and persistent (as identified in other fisheries by Hintzen *et al*. (2019)). This activity is probably targeting areas of higher scallop abundance (hot spots). Spatially clustered activity at trip level was identified using the DBSCAN clustering method (Ester *et al*., 1996) and, as an additional step, pings were filtered out that were outside the main cloud of VMS points for a given trip because they are unlikely to be fishing activity. DBSCAN is a density-based cluster algorithm capable of identifying clusters of arbitrary shape. It requires the definition of two initial parameters relating to the minimum number of points that could define a cluster, as well as the expected distance between pings that cause clustering patterns. Work continues to refine this methodology, but successful results have been obtained so far (Figure 2). This method will help in a better definition of fishing activity for scallop dredgers and may enable estimation of fishing mortality rate (depletion) of scallop stocks at local level.

Inspired by the previous work of Murray *et al*., (2013) we also calculated swept-area for each VMS fishing ping, as a product of the number of dredges, ping speed, time interval between consecutive fishing pings and the number of dredges on each boat. Thus, for each ping, we could define landings per unit of effort (LPUE) in terms of kilogrammes of scallop landings per unit of area. Future work will focus on the development of standardized indices of abundance for the area, following on the previous work (ICES, 2021) the WG has conducted using spatial-temporal models such as the VAST model (Thorson, 2019).

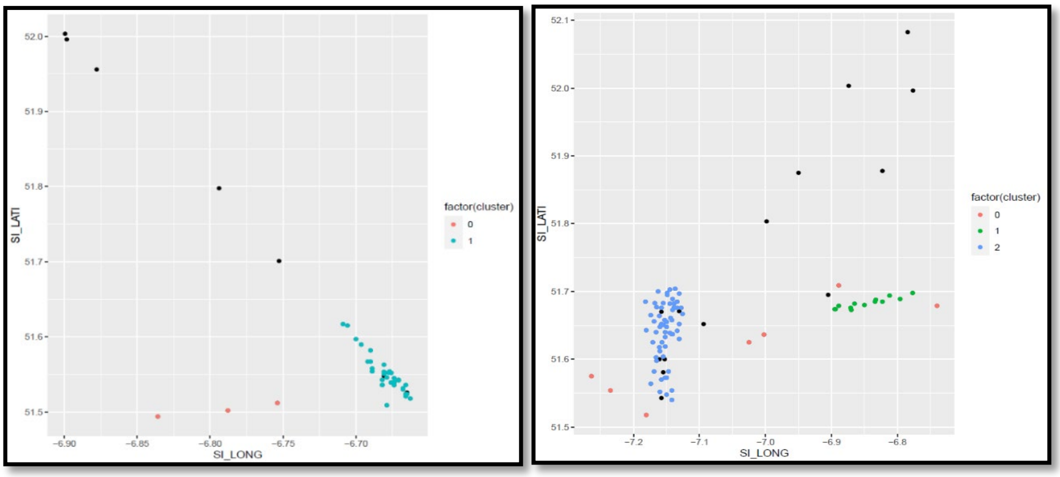


Figure 2 Each plot displays all pings of a particular trip from a boat belonging to the Irish scallop fleet. Black pings are VMS points above or below the speed threshold (0.8–4 knots), and thus are removed from analysis. Coloured pings are classified by the DBSCAN clustering algorithm. Positive values (above 0), are identified as single individual clusters, whereas pings classified as 0 (pink colour), do not follow the general aggregation behaviour, and are thus removed from consequent analysis.

4 ToR D Review and report on current scallop surveys and share expertise, knowledge, and technical advances. Review electronic monitoring (EM) for scallop fisheries.

Scallop surveys continue to be an important data source for the stock assessment in many areas. In recent years, there have been multiple disruptions and funding, or vessel availability, have been issues for some institutes. These issues have been addressed and most planned scallop surveys were successfully completed in 2022 (Table 3). WG members have agreed to scientific staff exchanges in 2023 if permissible (there continues to be limits on staff numbers aboard vessels, and members noted that permission to travel and funding may prove problematic).

Table 3 A summary of scallop surveys and any issues or disruptions 2020–2022.

Country	Target species	Typical/planned surveys	2020 Covid-19 disruption	2021	2022 Update	Other issues (weather/funding/ship/staff)
England	King scallop	Annual dredge survey Western English Channel and Celtic Sea (selected areas)	Delayed from May to August	No Covid disruption	Completed May 2022	Logistics prevented survey in assessment area 27.7.f.I
England	King scallop	Annual dredge survey Eastern English Channel and North Sea (selected areas)	Completed to schedule	No Covid disruption	Completed September 2022	Recently defined survey area 27.4.b.D not carried out
England	King scallop	UWTV survey in selected unexploited areas	Cancelled	Relocated from English Channel to North Sea	Scheduled November 2022	
France	King scallop	Annual survey, Bay of Saint-Brieuc (VIIe,26e7)	No Covid disruption	No Covid disruption	Completed September 2022	Old vessel (44 years old) which will be replaced from 2024 onwards
France	King scallop	Annual survey, Bay of Seine (7d,27E9 and 28E9)	No disruption, but effect on sampling design (only French territorial waters assessed 27E9)			
Iceland	Iceland scallops	Annual drop camera survey	No Covid disruption	Cancelled	Scheduled in 2023	Cancelled due to lack of funding

Country	Target species	Typical/planned surveys	2020 Covid-19 disruption	2021	2022 Update	Other issues (weather/funding/ship/staff)
Ireland	King Scallop	Dredge Survey	No covid disruption	No covid disruption	Scheduled December 2022	
Ireland	King Scallop	Dredge survey - Celtic Sea and Tuskar	No survey	No Survey	Scheduled in 2023	Last done in 2019. Survey to be carried in 2023
Ireland	King Scallop	Dredge Survey - North Irish Sea			Scheduled in 2023	New survey
Isle of Man	King and queen scallop	Annual scientific survey	Delayed from April to September and then cancelled due to border restrictions and quarantine regulations for staff	Went ahead adhering to CV regulations (i.e. reduced scientific staffing due to ongoing CV regulations and two-week isolation post-survey)	Completed April 2022	
Isle of Man	King and queen scallop	Annual Industry survey	Went ahead adhering to CV regulations	Went ahead adhering to CV regulations	Completed April 2022	Industry research funding scheme set up last year to support financing of this survey - permits given to vessels to land any scallops over the daily catch limit on last tow and the value of these attributed to a research fund which will help finance the survey each year.
Jersey	King scallop	Annual dredge survey, started 2021	None	Initial baseline survey completed, refining method for 2022	2022 survey completed September. 44 sites.	
Northern Ireland	King scallop	Annual dredge survey	No Covid disruption	No disruption	Completed Feb 2022	Funded through Department of Agriculture, Environment and Rural Affairs
Northern Ireland	Queen scallop	Annual UWTV and fishing survey (June/July)	Cancelled	No disruption - survey back to normal	Completed July 2022	Funded through Department of Agriculture, Environment and Rural Affairs

Country	Target species	Typical/planned surveys	2020 Covid-19 disruption	2021	2022 Update	Other issues (weather/funding/ship/staff)
Norway	Iceland scallops	Irregular scientific survey	No Covid disruption	No survey	Completed September 2022	
Norway	King scallop	Irregular scientific diving survey	Cancelled	Cancelled	Completed June 2022	Funded by the Norwegian Ministry of Trade, Industry and Fisheries
Scotland	King scallop	Annual dredge survey - Shetland (15 days)	No Covid disruption	Reduced scientific staff and crew reduced sampling capability, vessel in port every night	Completed - Jan/Feb 2022	
Scotland	King scallop	Annual dredge survey - West coast of Scotland (21 days)	Cancelled	Reduced scientific staff and crew reduced sampling capability, vessel in port every night	Completed - May 2022	
Scotland	King scallop	Annual dredge survey - East coast of Scotland (20 days)	Cancelled	Reduced scientific staff and reduced sampling capability	Completed - July 2022	
Scotland	King scallop	Dredge survey - Clyde (14 days)	Cancelled	Disrupted due to Covid, Half survey complete	Due November	
USA	Sea scallop	Annual drop camera survey	Limited disruption	Survey completed	Survey completed	
Wales	King and queen scallop	Annual survey	Delayed from April until August in 2020. Reduced scientific crews prevented camera sampling at night and	Reduced scientific crews prevented camera sampling at night and resulted in loss of bycatch processing at a small	Completed April 2022	

Country	Target species	Typical/planned surveys	2020 Covid-19 disruption	2021	2022 Update	Other issues (weather/funding/ship/staff)
			resulted in loss of by-catch processing at a small number of stations.	number of stations.		

4.1 Norway update. King scallop (*Pecten maximus*)

A commercial diver fishery for king scallop was developed in Norway during the early 1990s, with the main fishing area at Frøya in Trøndelag County (ICES assessment area IIa). Since 2013, a new fishing area was established at Helgeland (Nordland County), north of Trøndelag. In the period 1999 to 2019 the total landings ranged between 400–900 tonnes (Figure 3), and while the landings in Trøndelag have decreased from a maximum of 892 tonnes in 2008 to 136 tonnes in 2021, landings at Helgeland have been quite stable (106–235 tonnes per year). In 2021 the total landings were 290 tonnes, where 136 tonnes were landed in Trøndelag and 154 tonnes lands in Helgeland. The decrease in landings in Trøndelag is assumed to be a result of the economic depression (2009), implementation of new diver regulations (2015) and lately the Covid-19 pandemic (2020–2021) rather than overfishing.

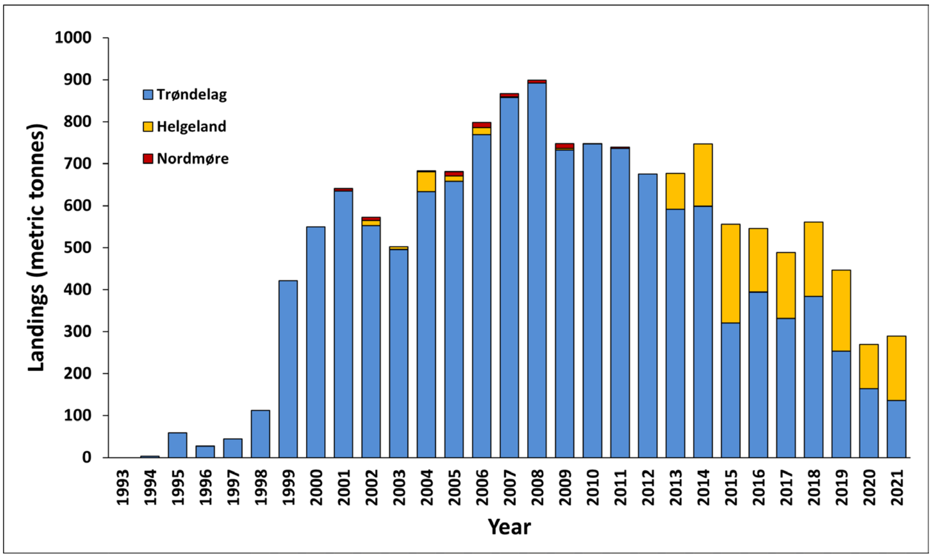


Figure 3 Landings of king scallop (*Pecten maximus*) into Norway by divers in the period 1994–2021. Data from the Norwegian Fishermen's Sales Organization.

Since the fishery developed, the possibility of overexploitation 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 fishers 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 fishers.

The Institute of Marine Research (IMR) has irregularly surveyed the fished stocks since the mid-1990s to assess age distribution (1993, 1997, 2006, 2007, 2010 and 2022). Comparing the age distribution (percentage of each year class represented in the sampled scallops) from the period 1993–2010 with 2022 shows that all year classes from one to eight are represented, although the domination of certain age groups varies (Figure 4).

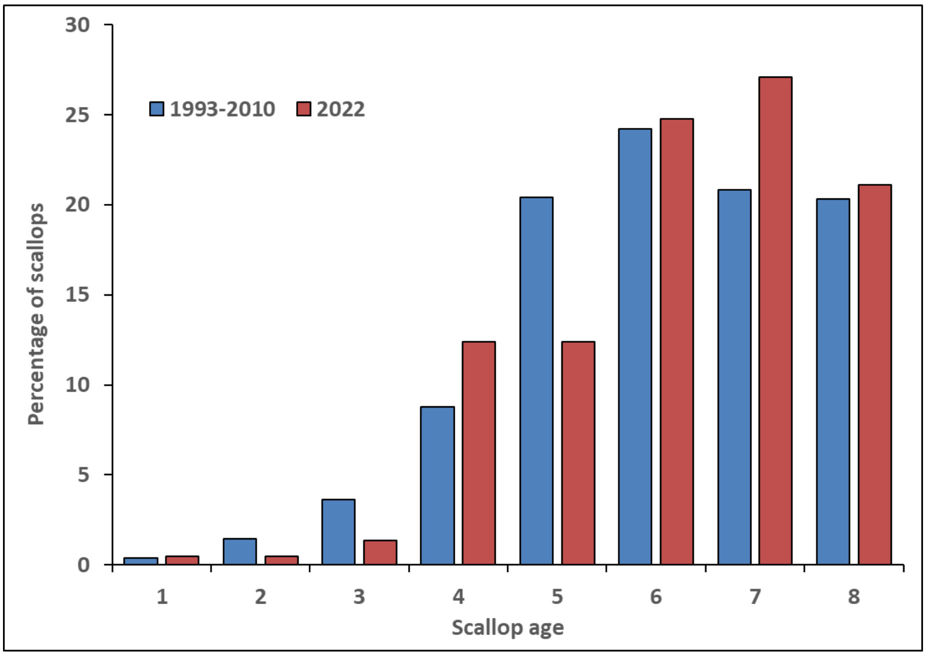


Figure 4 Percentage of each scallop age group of the sampled scallops in the period 1993–2010 and 2022. The survey area was at Frøya in Trøndelag County (assessment area IIa).

The last IMR diving survey in the main fishing area of Frøya/Hitra in Trøndelag was conducted in June 2022. In 2017 and 2018 diving and video surveys were conducted on the northernmost registered king scallop populations in the Lofoten area. In 2019 to 2021 there was no survey activity due to lack of funding (2019) and Covid-19 (2020–2021).

Due to the latest regulations of scientific diving, alternative survey methods are discussed such as video surveys, obtaining scallop age data from the shellfish distribution company or building a small dredge that can be used in areas with a high degree of variation in topography and sediment.

As a part of the "National marine habitat mapping program" areas of high abundance of *P. maximus* were mapped in Norwegian coastal areas using a vessel-towed camera platform collecting real time video along survey lines. These lines are chosen to combine topographic information from sea maps with anecdotal knowledge of scallop distribution patterns. During 2009–2019, data from a total of about 850 tows from Rogaland (South-Western Norway) to Nordland (North Norway) Counties have been collected. It was possible to do coarse estimation of scallop size based on the video recordings, but it was not possible to do age reading. Additionally, scallops less than 5 cm shell height are hard to detect and are highly underrepresented in the video survey data. Video surveys can be used as a supplementary survey method but cannot substitute for obtaining live scallops for measures of size and age. During the 2022 survey, divers conducted underwater transects in addition to the traditional sampling. A 25-meter-long rope was placed on the seabed and the diver held a 3-meter-long pole (marked in the middle, 1.5 m, with black tape) in front while swimming slowly along the rope. The number of scallops within the 3x25 m transect were counted, the habitat was described, and flora and fauna were recorded. On average, divers collected 37 scallops per sample dive and observed 37.5 scallops per transect dive (5-6 transects per dive). Data needs to be analysed in more detail and discussed before any conclusions are drawn but based on the preliminary analysis video transects may supplement data on scallop density and distribution in an area.

Data on individual diver catch-per day (CPUE) has been extracted from logbooks during the period 2003–2015 and data on regional catch are collected from the statutory marketing data. These data, combined with the survey results, are used to advise on the king scallop stock.

4.2 Norway update. Iceland scallops (*Chlamys islandica*)

After a substantial fishery for Iceland scallops developed in the Svalbard area in the late 1980s, the fishery collapsed and was subsequently closed in the early 1990s. Since then, no fishing for Iceland scallops took place in Norwegian waters. However, after conducting surveys around Bjørnøya and on Spitsbergenbanken in 2019 and 2020, it was concluded that the stock has recovered and a maximum sustainable yield (MSY) of 15000 tonnes round weight for three major scallop beds was advised based on a data-limited management strategy evaluation (MSE). In connection with the development of new gear technology that has been shown to be less damaging to the benthic habitat than dredging and therefore avoids falling under the Norwegian dredge ban, the authorities allowed a trial fishery starting in 2022. Currently, two fishing vessels have received licenses to operate under the conditions of the trial fishery that include a total allowable catch (TAC) based on the MSY quota advice and comprehensive reporting requirements. The reported data will be used to monitor the development of the fishery and establish a stock assessment and advice framework.

The opening of a trial fishery renewed interest to assess the state of the scallop beds north of Svalbard. This area, notably the scallop bed north of the Moffen island, represented a major fishing ground in the previous fishery and could therefore sustain a sizeable harvest. IMR surveyed in September 2022, including both the scallop beds around Moffen and on Parryflaket, covering both areas inside and outside the current protected zone. In total 79 stations were covered, the large majority with a video sledge to assess the density of scallops. In addition, biological samples were collected at 13 stations by dredging, to gain information on size frequencies and stock composition, and for analysis of population genetics and contaminants. At the time of reporting, results are not available, however initial observations indicate a recovery to similar densities as observed prior to the onset of the fishery in the 1980s. Detailed analysis and stock estimates will be presented at the WGScallop meeting in 2023.

4.3 Iceland (Chlamys islandica)

The main Iceland scallop (*Chlamys islandica*) beds in Breiðafjöður, western Iceland, were surveyed with a drop frame camera annually during 2014–2019. Catches and biomass indices are available for that period (Figure 5). No surveys have been conducted since then, mainly because of budget constraints.

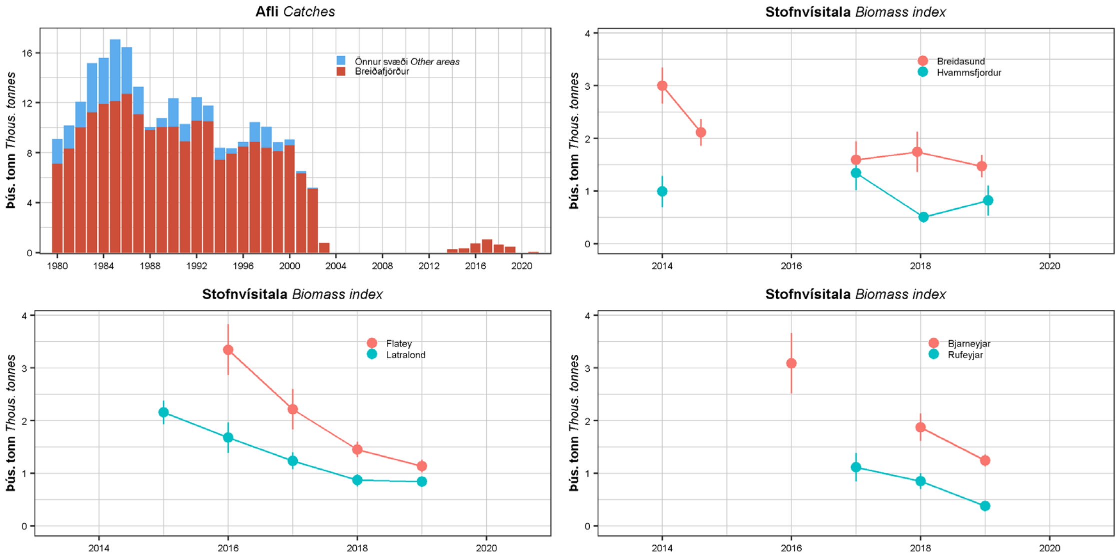


Figure 5 Catches and biomass indices from surveys on dredged grounds in Breiðasund and Hvammsfjörður 2014–2019, Flatey area and Látralönd in 2015–2019, and Bjarneyjar and Rúfeyjar 2016–2019.

For the past two fishing years a TAC of 93 tonnes was proposed on two grounds (Breiðasund and Hvammsfjörður) in the southern part of the fjord where the abundance of scallops has been relatively stable. Due to limited fishing and no new information on biomass the advice was the same for the fishing year of 2022/2023.

4.4 North America. Sea scallop (*Placopecten magellanicus*)

The drop camera survey of sea scallops in the Western Atlantic was conducted by the School for Marine Science and Technology (SMAST) as planned in 2022. The scallop data from this survey are combined with those from two other surveys of the stock (dredge and a towed camera survey) conducted by other institutes, and feeds directly into a length-based stock assessment model with forward projection capabilities run by the National Oceanic and Atmospheric Administration (NOAA). The survey was completed in six separate week-long trips using six different commercial scallop vessels (Figure 6). Survey stations followed a systematic grid design with stations 0.58, 1.5 and 3 nautical miles apart in different management zones. The choice of these grid sizes in each area was driven by funding decisions and local priorities guided by an external panel of scientists. At each station the camera system was dropped to the seafloor four times to take four photographs. The vessel drifted with the tide when conducting the quadrats and therefore the distance between each quadrat was typically 50 meters. The photographs were digitized on land by staff and then quality checked by experienced researchers before being stored in a local database. This process obtained counts of sea scallops and approximately 50 other species and species groups, as well as quantifying the percentage cover of seabed substrate.

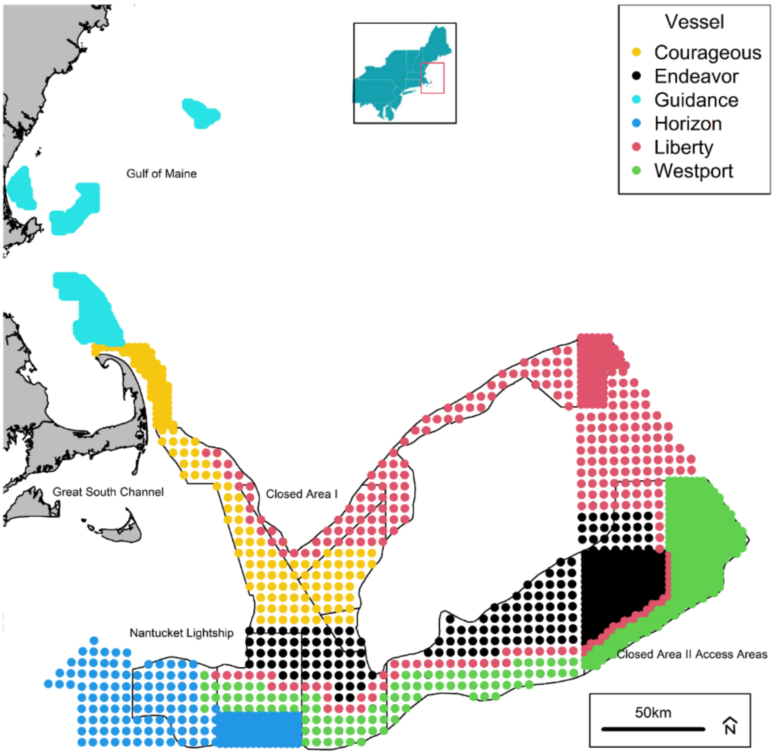


Figure 6 A map of station locations sampled by the SMAST drop camera survey in 2022. The station locations are coloured by trip, with each trip corresponding to a unique fishing vessel. All coloured points apart from cyan are in the Georges Bank region. The cyan points are in the Gulf of Maine. The grey land is the east coast of Massachusetts.

The resulting spatial scallop densities were similar to the previous year, although high densities of less than 35 mm shell height scallops were identified in several regions. Overall, this survey estimated a considerable abundance increase of around 1,500 million scallops on Georges Bank but a decrease in biomass of around 40,000 metric tonnes. This coincides with approximately 50% of the scallops measured during this survey being less than 40 mm in size (Figure 7). These estimates were largely consistent with the data from the other two surveys. The survey data from the Gulf of Maine showed similar patterns to the previous year, with larger average scallop sizes than Georges Bank.

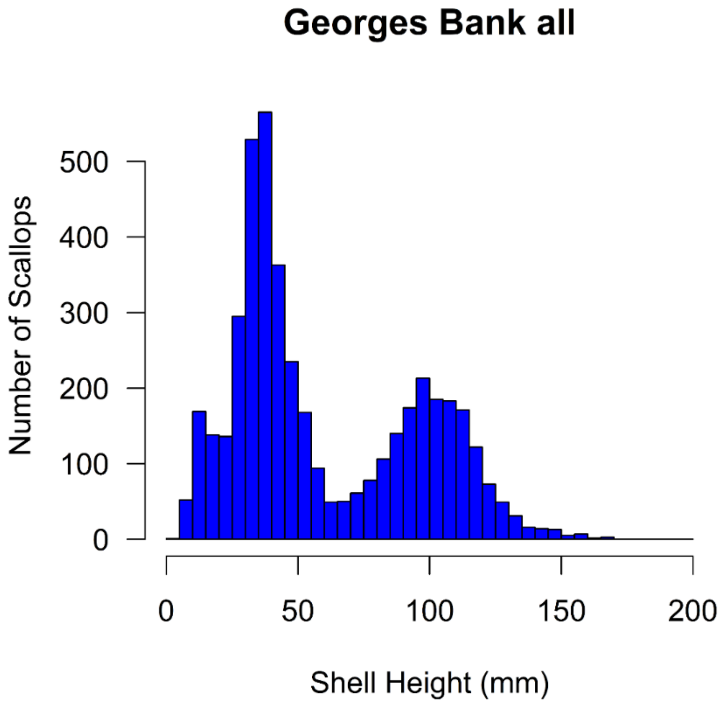


Figure 7 A histogram displaying the counts of shell heights (mm) of scallops measured by the SMAST drop camera survey on Georges Bank in 2022.

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

AFBI carried out their annual scallop survey in February 2022 with the survey now having an unbroken 30-year time-series. During the 2022 survey, 41 stations were fished using a single tow bar fitted with four commercial sized dredges, one of which was lined with a fine mesh to retain small animals (both scallops and bycatch). Scallops were caught at all but two of the stations. All scallops were processed in terms of damage score, shell age, total weight, shell length and breadth, gonad weight and stage and muscle weight. Figure 8 shows the catch by tow around the NI coast. In 2022, 14 of the randomly selected stations were the same stations as what were sampled during the 2021 survey. Of these stations, seven showed an increase in catches from 2021 to 2022, with the remaining seven showing a decrease in catches. Examination of survey CPUE (number per 100 m^2 swept) between 1992 and 2021 shows that in recent years, while there has been a small upward turn in the 2022 survey, CPUE has decreased from a peak in 2012–2014 (Figure 9).

During the survey, all bycatch was identified. In total 67 taxa, including *Pecten maximus*, were recorded. While the Chordata were the most diverse group with 24 species reported, the Echinodermata were the most predominant group. The common starfish (*Asterias rubens*) was the most abundant bycatch species and was found at 28 of the stations surveyed. The queen scallop (*Aequipecten opercularis*) was the second most abundant species and the edible urchin (*Echinus esculentus*) the third most abundant. The proportion of the catch made up of bycatch species ranged from 19% to 77%.

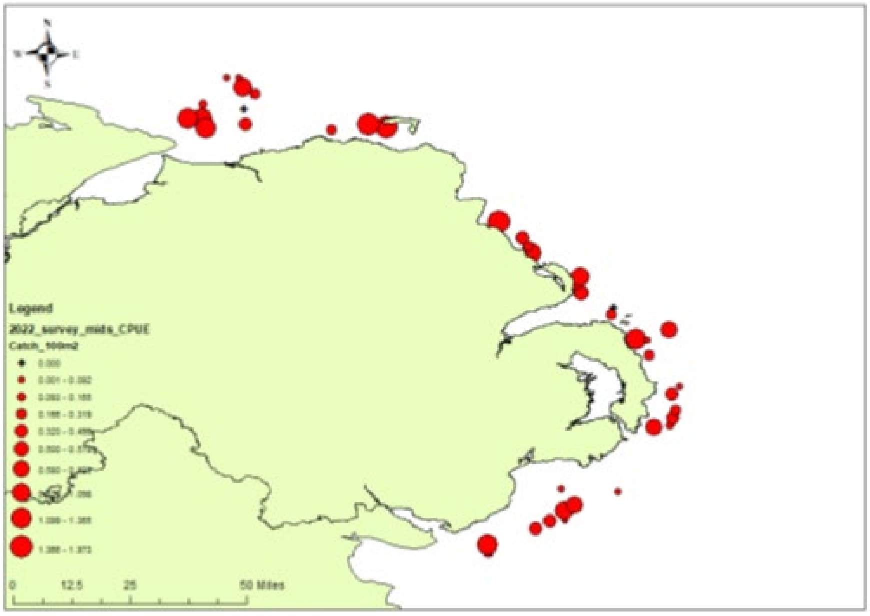


Figure 8 Position of the midpoint of tows completed during the AFBI 2022 survey. The size of circle is indicative of the scallop catch per 100 m².

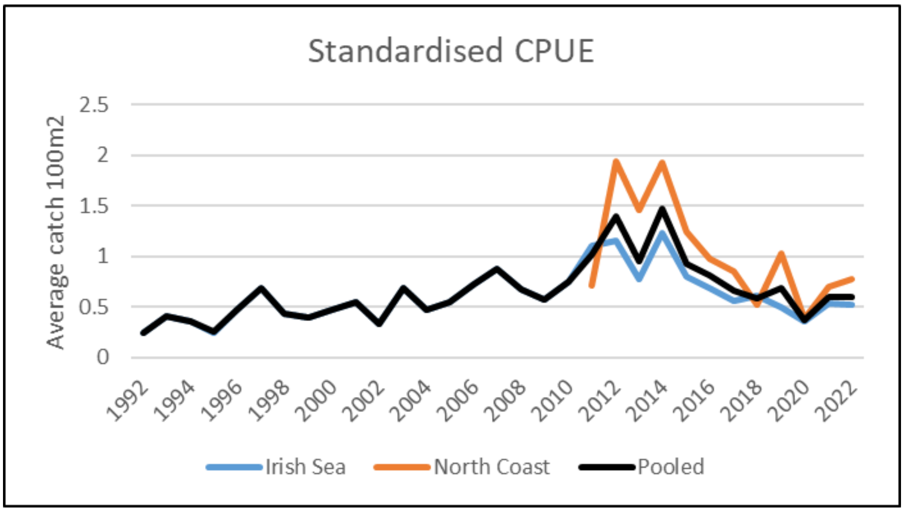


Figure 9 AFBI survey catch per unit effort (CPUE) from 1992–2022.

4.6 Northern Ireland. Queen scallop (*Aequipecten opercularis*)

In July 2022 AFBI completed their annual queenie survey. The survey is based on Under Water Towed Video (UWTV). A total of 94 camera tows were carried out during the survey (52 in the Irish Sea and 42 along the North Coast). At each station the sled and camera were deployed and towed for 15 minutes at a speed of 0.8-1.2 knots. The number of queenies per minute were counted for the camera tows. Based on the results of the counts, stations were selected for fishing. These selected stations were fished using a system of dredges (fitted with two king scallop dredges, one of which is fitted with a fine mesh liner, and two queen scallop dredges) or a queenie net.

Eight stations across the survey area (two in the Irish Sea and six along the North Coast) had zero counts of queenies. The highest density of queenies reported during the UWTV survey was within the East Douglas closed area (193 per 100 m^2). The Irish Sea had the greatest abundance of queenies averaged over all the camera tows (45.06 per 100 m^2); the North Coast had an average abundance of queenies of 37.27 per 100 m^2 over all the camera tows (Figure 10).

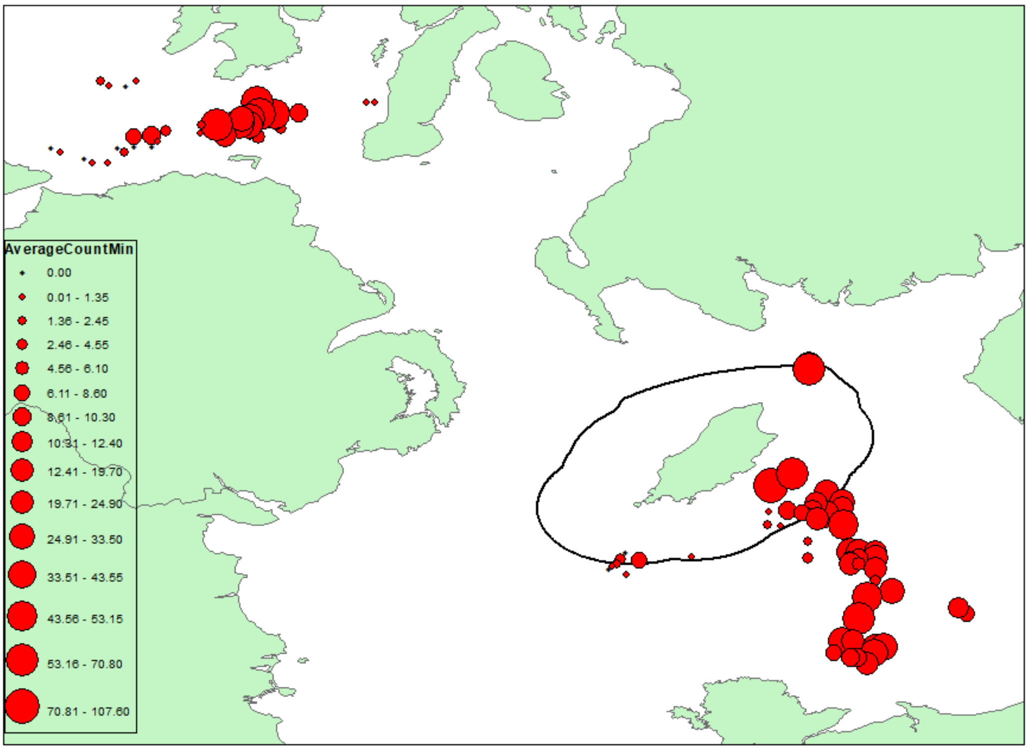


Figure 10 Average abundance of queenies (counts per minute) as recorded during the UWTV survey (unstandardized by area (m^2) surveyed) in 2022.

Using biological information (lengths and weights) collected during the fishing tows, biomass was estimated for both regions. Estimated biomass has increased for both the Irish Sea and North Coast in 2022 (Figure 11).

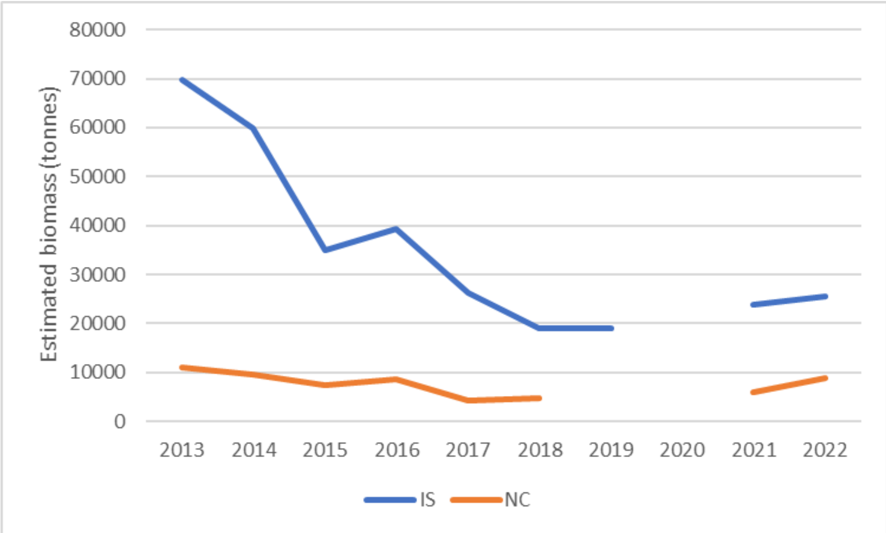


Figure 11 Estimated biomass of queenies as reported from the AFBI survey.

4.7 Scotland. King scallop (*Pecten maximus*)

Marine Scotland Science (MSS) have conducted dredge surveys for king scallops for at least 40 years, previously using commercial boats, but more recently our own research vessel which, since 2008, has been the MRV *Alba na Mara*. The survey aim is to collect catch rate data for the stock assessment process.

In the past MSS typically conducted three annual scallop surveys; the east coast of Scotland, the west coast and Shetland, with 332 fixed stations in total. In 2019 and 2021 the Clyde was added. The surveys now cover six of our assessment areas but does not include Orkney or the Irish Sea (Figure 12).

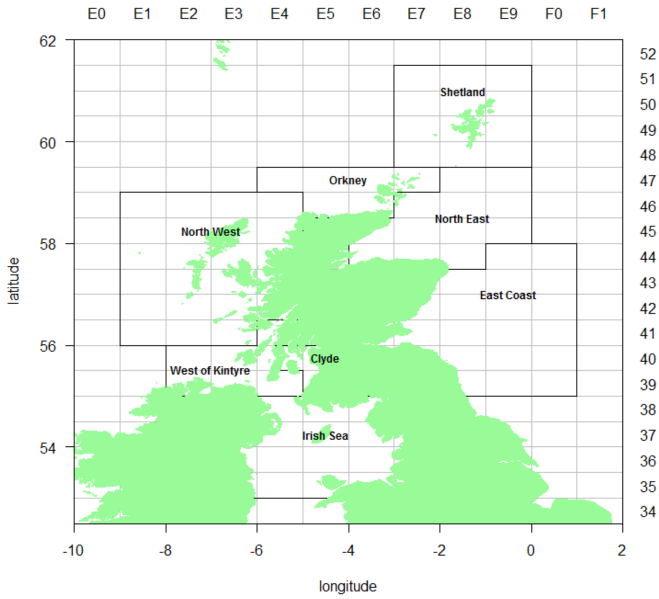


Figure 12 Map of MSS king scallop assessment areas. Scallop dredge surveys now cover six of the assessment areas (but not Orkney or the Irish Sea).

The scallop dredge surveys follow a fixed station design, originally determined with reference to British Geological Survey charts to locate sediments suitable for scallops and using fisher knowledge of the fishing grounds.

At each station, spring loaded Newhaven type dredges are towed for approximately 30 minutes at a speed of ca. 2.5 knots. The dredges are fished six aside, with a total fishing width of 9 m. The starboard dredges are similar to those used in the commercial king scallop fishery and consist of 6x9 tooth bars and 80 mm belly rings. The port side is rigged with the scientific dredges, 6x11 tooth bars and 60 mm belly rings (similar to those used for queen scallop fishing), to catch undersized scallops.

All scallops caught are measured, aged and damage is assessed. Bycatch is collected, identified, measured and damage is assessed where appropriate. Data related to each tow are recorded including positions, depth, sea conditions, salinity, and more. Any additional requests are also carried out if possible. This year the objectives were:

- To carry out a survey of scallop stocks around the coast of Scotland.
- To age, measure and assess shell damage on all scallops caught.
- To collect whole scallops for heavy metal testing as part of the OSPAR assessment of hazardous substances in the marine environment.
- To collect information on bycatch of other commercial fish and shellfish species.
- To identify and quantify numbers of starfish species in all dredge tows.
- To record and retain marine litter obtained during the dredging process (for MSFD).
- To collect samples for genetic testing.
- To collect shells for aging training.
- Measure meat weights and rings (Clyde only).

During the surveys carried out since the last ICES meeting (Table 4), a total of 230 stations were sampled covering 34 ICES statistical rectangles in six assessment areas. A breakdown of the number of stations, scallops and bycatch is provided (Table 4).

Table 4 A summary of MSS scallop surveys completed since the last WG meeting (October 2021–July 2022).

Survey	Area	Start date	End date	Stations	Scallops	Bycatch
1421A	Clyde	14/10/21	25/10/21	31	2709	4703
0222A	Shetland	26/01/22	13/02/22	42	8753	3740
0622A	West coast	01/05/22	19/05/22	63	7783	3950
1022A	East coast	15/07/22	02/08/22	94	7456	3412

The number of stations sampled this year is slightly down on previous years. Several factors contributed to this decline including bad weather and vessel mechanical issues, and Covid-19 continues to cause disruption with four surveying days lost on the Clyde survey. New wind-farms on the East coast survey and creels on the East and West coast surveys also resulted in several stations being inaccessible.

During 2023, MSS hopes to carry out all four of our annual surveys, complete a scallop stock assessment, design, and produce a survey report and upgrade standard operating procedures including gear validation and traceability.

4.8 France, Bay of Saint-Brieuc. King scallop (*Pecten maximus*)

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 area divided in six spatial strata (survey COSB 2022; 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 periods from 2020 onwards.

The onboard operations usually undertaken in the late summer involve sampling 115 stations by dredging for 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 very high densities of scallop beds in the Bay of Biscay implies that for most tows the dredge bag (height of 22 rings) is systematically half or completely filled after 200 m of distance (2'15-2'45 of duration against current or against the bisecting current/wind direction). The dredge efficiency is calibrated to previous references (Fifas and Berthou, 1999; Fifas *et al.*, 2004). Caught individuals are aged and a length frequency distribution (LFD) by age group and tow is obtained.

The inshore King Scallop fishery of the Saint-Brieuc Bay is typically among the highest density levels in Europe. For the period 1962–2022, landings usually oscillated in the range of 4000–6000 tonnes with some extreme values at 12500 tonnes (season 1972/73) and 1300 tonnes (season 1989/90). In recent years, the exploitation has been undertaken by 220–230 vessels (96-98% dredgers, 2–4% divers). Many historical stages, throughout more than a half century of exploitation (from the early 60's onwards), of this stock are influenced by management regulations: licence system by pair skipper/vessel (1973), global quota/TAC (1974), obligation of landings at auction (1978), improvement of selectivity pattern (ring diameter for dredges: 72 to 85 mm in 1985, 85 to 92 mm in 1997, 92 to 97 mm in 2017)

The adult biomass index includes all age groups ≥ 2, it provides a proxy of the stock fecundity. The exploitable biomass corresponds to individuals larger than 102 mm (minimum landing size (MLS) in VIIe French waters), thus it is less than the adult biomass. These indices show cyclical pattern with a downwards trend in the period 2006–2013 (-53% and –57% for adult and exploitable biomass, respectively). Afterward, biomass increased. Since 2018, the stock biomass has steeply increased. In 2020–2022, the absolute records for adult and exploitable biomass were reached (+54% and +43% between 2019 and 2020, +11% and +19% between 2020 and 2021, +24% and +5% between 2021 and 2022, respectively).

The recruiting class abundance is estimated at 286 million (24 840 tonnes, among them 2160 tonnes immediately exploitable, 14450 tonnes in the middle of fishing season *i.e.* January 2023). This value is the historically highest-level value compared to the last two years. These two most recent years were previously the maximum observed abundances for age 2 (152 and 160 million).

The management policy attempts to preserve more than one significantly abundant age groups, with the aim of reducing fluctuations between annual total abundance within the recruitment variability range. Four older age groups are significantly abundant in the fishery: 3–6 years (respectively 20 570 tonnes, 12 680 tonnes, 8630 tonnes, 6950 tonnes). The total remaining biomass was estimated at 48 830 tonnes (43 990 tonnes in 2021, 37 050 tonnes in 2020 and 26 930 tonnes in 2019). The 2019 cohort is represented by a total abundance of 163 million (the previous highest values were estimated in 2020 and 2021: 111 and 108 million, respectively), among them 74% reached the MLS=102 mm (16 220 tonnes of a total biomass of 20 570 tonnes).

In late August 2022, the age group 1 was estimated at 487 million individuals (this abundance is expected to provide a total of 198 million individuals in the 2023 survey according to the expected mortality and growth rates for this age class. The 487 million individuals succeed the previous records from 2020 and 2021 (417 and 430 million). It is noticeable that the majority of historically high recruitment (threshold of 200 million) occurred from 2015 onwards: six out of eight of these years this threshold (all apart from 2015 and 2018) compared to only five years reaching this threshold from 1973–2014.The year class abundances for 2022–2024 are not yet known. The 2022 cohort abundance will be reliably estimated in the late summer of 2023. The input values for the three cohorts from 2022–2024 will be simulated. The simulation considers that the Beverton and Holt stock recruitment model explains a very low ($\varrho^2 \approx .10$) part of the predicted cohort abundance. The uncertainty in this relationship can be expressed by a lognormal probability. On this basis, recruitments for cohorts from 1989–2021 (surveys 1990–2022) were assigned to probability levels from the spawning biomass[1] of the birth year.

There are no other surveyed species or stocks in French fisheries where reliable projections three years ahead are possible. The partnership between scientists and the fishing industry (project FEAMP 28 on years 2017–2019 extended to the period 2020–2022) exists to guarantee the durability of the whole study. A new national funding project is being considered for the years 2023–2025. In the current partnership, the survey at sea provides accurate estimates for GR1+ whereas the age-size structured stratified biological sampling of landings allows the calculation of all fishing mortality components for GR2+ and the spat collectors for GR0 gives the first semi-quantitative estimate by cohort.

The management regulations allow for smoothing of decreasing patterns when the unavoidable weak cohorts arrive, although the regulations cannot completely offset cyclical phenomena nor

[1] The spawning biomass differs with age because the number of eggs is related to the scallop size.

the global warming trend.**Table 5 The 2022/2023 season proposed quota. 1st column: proposed quota(t); 2nd column: actual nominal landings (t); 3rd column: Δf=% variation for fishing effort between 2021/2022 and 2022/2023; 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.**

							Log-normal p=0.5			Cyclical log-normal p		
Option	Quota	Landings	Δf (%)	ΔY1 (%)	ΔY2 (%)	ΔY3 (%)	ΔBf1 (%)	ΔBf2 (%)	ΔBf3 (%)	ΔBf1 (%)	ΔBf2 (%)	ΔBf3 (%)
1	7141	8031	-25.5	0.0	22.2	14.7	9.6	2.8	-9.8	9.6	4.6	-6.1
2	7450	8326	-22.4	3.7	21.1	14.1	8.9	2.3	-10.3	8.9	4.1	-6.6
3	8150	8988	-15.3	11.9	18.7	12.8	7.3	1.2	-11.4	7.3	3.0	-7.5
4	8600	9409	-10.7	17.1	17.2	12.0	6.3	0.5	-12.0	6.3	2.3	-8.1
5	9635	10364	0.0	29.0	13.7	10.2	4.0	-1.0	-13.5	4.0	0.8	-9.5

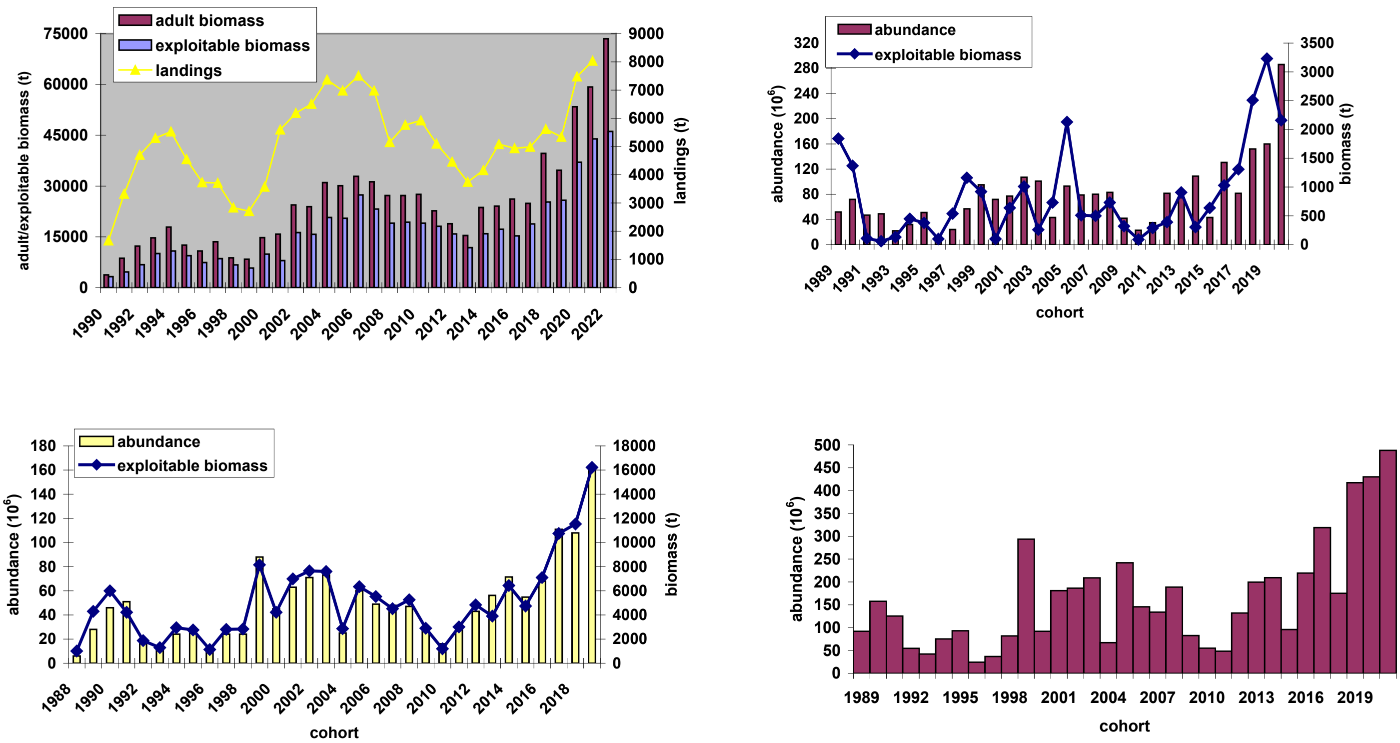


Figure 13 Saint-Brieuc Bay king scallop (1) Adult (yrs 2+) and exploitable biomass (≥102 mm), nominal landings. (2), (3) and (4) age group 2, 3 and 1 indices.

4.9 England. King scallop (*Pecten maximus*)

Two annual dredge surveys were carried out in 2022. The first in May covered the western English Channel and the second in September surveyed the eastern English Channel and North Sea. The approaches to the Bristol Channel were not surveyed in 2022 due to logistical issues. The recently defined assessment area in the Central North Sea was also not surveyed in 2022 as permission to dredge in the Dogger Bank special area of conservation (SAC) was not available at the time of the survey. A UWTV survey in the English Channel is planned in November this 2022. Data from these surveys will be used in the next assessment due early 2023.

Annual assessments have been presented to the group since the programme started in 2017 (2017–2021). The latest available report (Lawler, A and Nawri, N. 2022. [Assessment of scallops stocks 2020/21 - GOV.UK (www.gov.uk)]) incorporates data from surveys carried out in 2021.

The report describes the stock status of selected stocks surveyed 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.

In 2017, five stock assessment areas were identified as being of importance to UK fisheries: three in the western English Channel, ICES Subdivision 27.7.e (Inshore Cornwall, I; Offshore, O; Lyme Bay, L) and two in the eastern English Channel, 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). In 2021 a further assessment area 27.4.b.D (Central North Sea) was defined following a new fishery being discovered, primarily centred in the Dogger Bank SAC. However, a prohibition on the use of towed gears within the SAC has reduced fishing activity in this region and the future of the fishery in the wider area outside the SAC, and the need to assess stock status is currently unknown. The segregation of assessment areas is 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 (Figure 14).

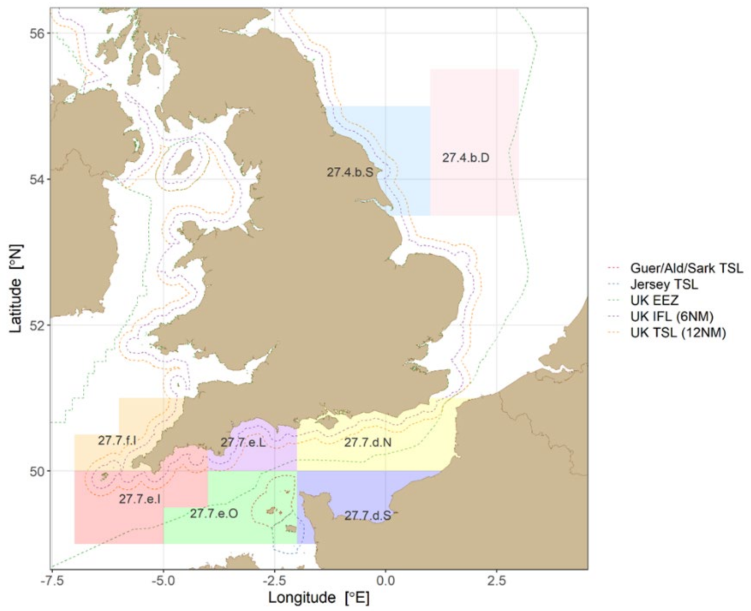


Figure 14 Stock assessment areas identified by the Centre for the Environment, Fisheries and Aquaculture Science (Cefas).

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, 4.b.S and 4.b.D 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 2017, in 7.e.O, 7.f.I and 7.d.N in 2019 and in 4.b.S and 4.b.D during 2021.

International landings were made available via last years' ICES WGScallop data call but those for the last two assessment periods were not available at the time of writing of the report. Harvest rates (HR) are calculated using realised landings taken from the stock over the 12 months following each survey and so HRs for 2020 are provisional estimates based on UK landings only. Provisional HRs for 2021 will not be available until the 2023 report.

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 estimated by the stock assessment (Figures 15-18). 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 VMS pings.

HR 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 MSY and HRs will need to be adjusted to compensate for this.

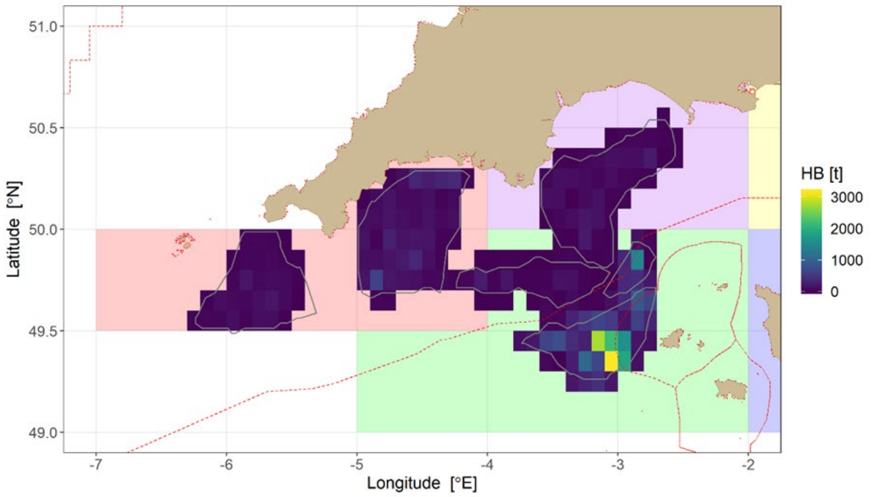


Figure 15 Harvestable biomass - Western English Channel (May 2021 dredge survey).

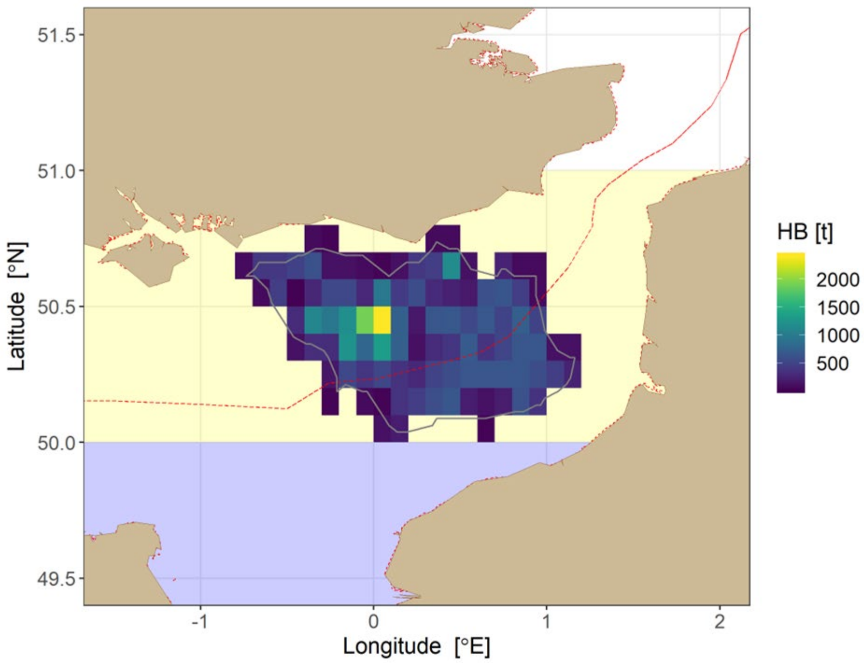


Figure 16 Harvestable biomass - Eastern English Channel (September 2021 dredge survey).

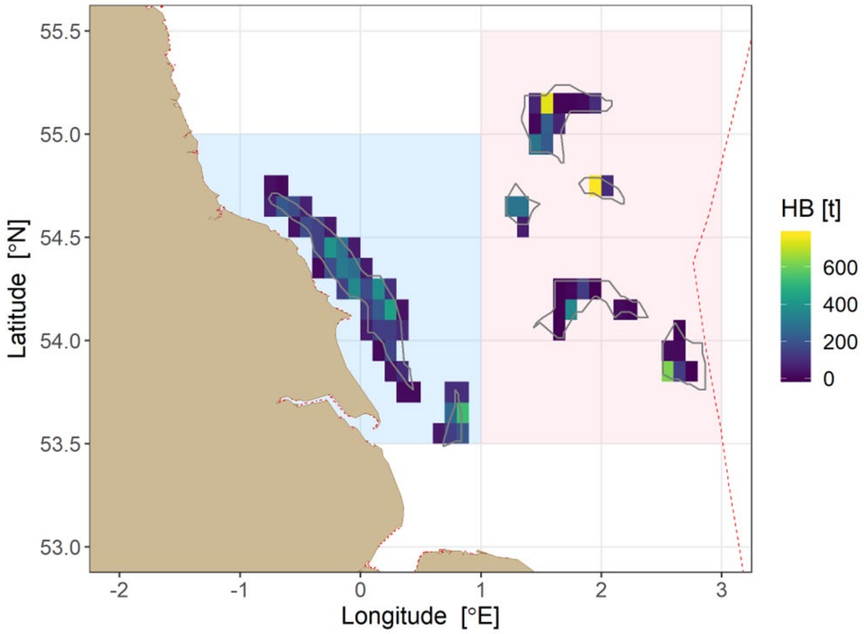


Figure 17 Harvestable biomass - North Sea (September 2021 dredge survey).

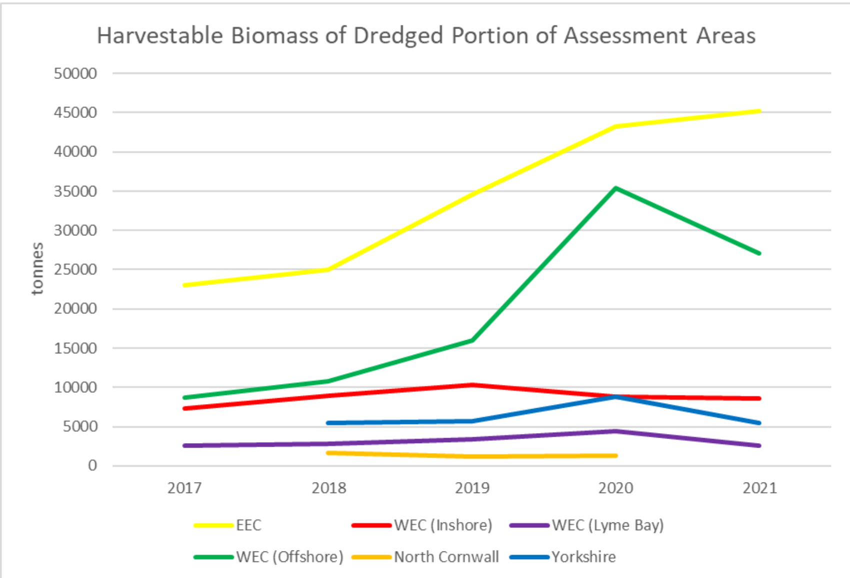


Figure 18 Trends in harvestable biomass by assessment area 2017–2021 (for Yorkshire/North Sea South 4.b.S 2018–2021 and Bristol Channel/North Cornwall, 7.f.I 2018–2020). WEC, 27.7.e and EEC, 27.7.d.N.

The potential HRs experienced by the surveyed portion of stocks were estimated by comparing international landings, or a proxy for them, to the available biomass estimates, for the dredged area only (Figure 19).

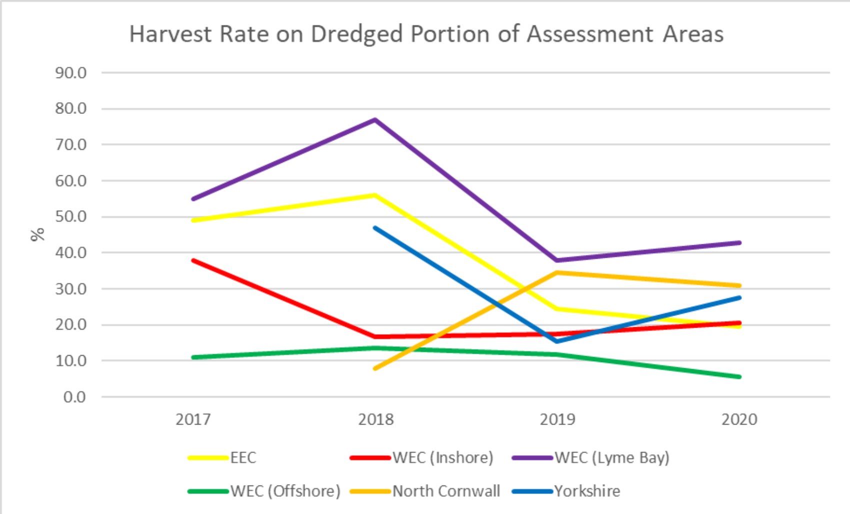


Figure 19 Trends in harvest rates by assessment area (2017–2020, for 4.b.S and 7.f.I 2018–2020). N.B. 2020 are provisional. WEC, 27.7.e and EEC, 27.7.d.N.

Cohort modelling was used to put realised HRs into context with proxies for MSY being estimated to be approximately 20% for each area. The residual HR is presented for four assessment areas where a cohort analysis was undertaken (Figure 20).

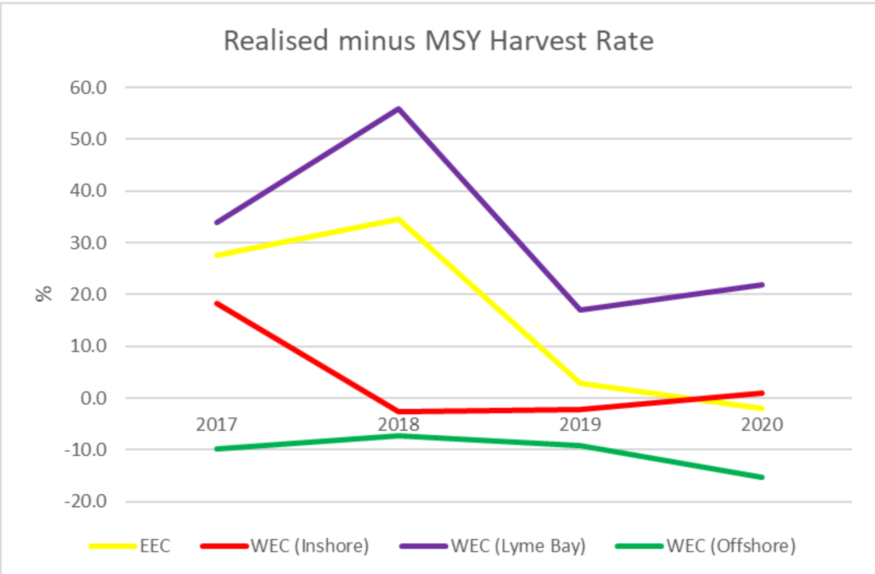


Figure 20 Residual harvest rates (realised – MSY proxy) for four of the assessment areas. WEC, 27.7.e and EEC, 27.7.d.N.

As this is only the fifth scallop stock assessment, which is considered a short period, 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 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.

For the 2020/2021 stock assessments Cefas intends to use international data provided to the WG to calculate HRs as a measure of exploitation (Table 6).

Table 6 International landings of king scallop by selected assessment area and survey year to be used to retrospectively estimate HRs in the Cefas 2020/2021 stock assessments. Source WGScallop data calls (2000–2021). [1] Survey year is defined as the 12-month period after each annual dredge survey.

Region	Assessment Area	Survey Year[1]	Landings (t)
North Sea	27.4.b.S	2017	2186
		2018	2594
		2019	889
		2020	2450
Eastern English Channel	27.7.d.N	2017	11260
		2018	14041
		2019	8429
		2020	11797
Western English Channel	27.7.e.I	2017	2773
		2018	1507
		2019	1801
		2020	1309
	27.7.e.L	2017	1450
		2018	2192
		2019	1284
		2020	2004
	27.7.e.O	2017	956
		2018	1460
		2019	1868
		2020	2717
Celtic Sea	27.7.f.I	2017	251
		2018	135
		2019	395
		2020	187

4.10 Wales. King scallop (*Pecten maximus*)

Bangor University leads an annual scallop survey within Welsh waters, and this has continued in 2022 (Figure 21). The survey included 61 dredge transects of 20-minute tows across three main scallop areas: Liverpool Bay, Llyn Peninsula and Cardigan Bay.

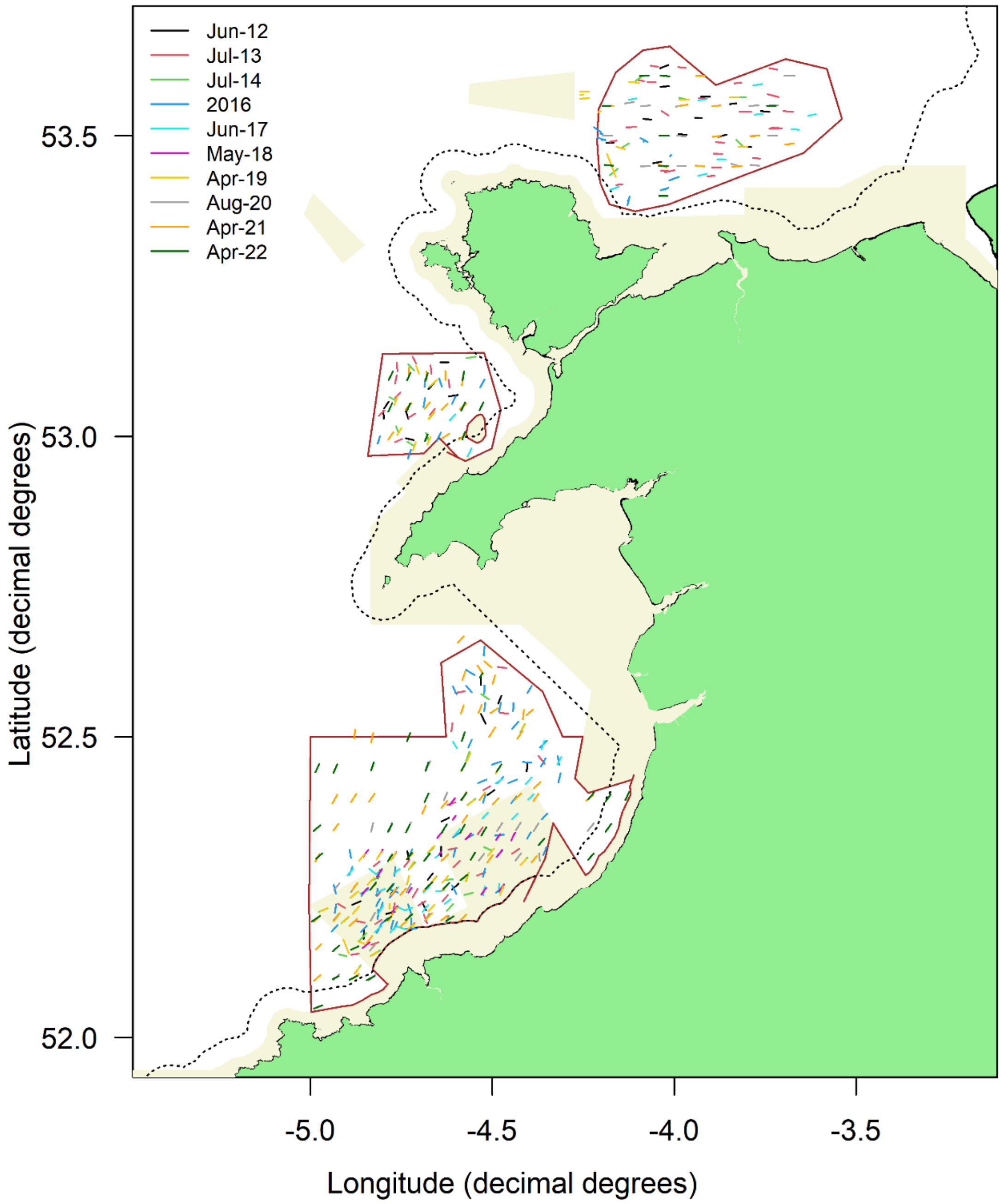


Figure 21 Annual scallop tows in Liverpool Bay, Llyn Peninsula and Cardigan Bay (2012–2022).

The survey collects data on scallop biomass/abundance, size frequency, age frequency, size at age and bycatch. Samples are retained from each survey station for analysis in the laboratory to collect data on gonad maturity, length-weight, and yield. The survey methodology has followed the methods in operation since the first survey in 2012. Work is being undertaken to incorporate a stratified random sampling design into the 2023 survey. Analyses of the 2022 survey is currently underway.

In addition to the annual fisheries independent survey, Bangor University has worked with the Welsh Government to access landings and VMS data for the time-series of 2012–2022. This aims to include landings and VMS for all vessels fishing in Welsh waters. Work is underway to link these VMS and logbook data and to standardize the landings per unit effort (LPUE). Difficulties exist in the analyses: inside the 12 nm limit VMS pings are every 10 minutes, between 12 nm and the midline there are two hourly pings. Different size vessels' VMS data were stored in different databases before 2022 and some of these have been archived when new databases were introduced. Work is underway to understand if there are any missing data and how best to account for missing data if this is the case. Aims are to understand the footprint of the fishing activity in Welsh waters to understand if the extent of the current annual scientific survey is sufficient (Since the EU exit Wales now has jurisdiction out to the midline, not just to 12 nm). In addition, if we can accurately link VMS and logbooks, we hope to apply biomass dynamics and age-based stock assessment methods at a more suitable spatial scale, as currently the assessment is applied at ICES statistical rectangle level. Finally, we hope to visualize any trends in LPUE within Welsh waters.

4.11 Jersey, Channel Islands. King scallop (*Pecten maximus*)

The 2022 king scallop survey was conducted over three days in September. Jersey is covered by four ICES rectangles, two of which include seas inside and outside Jersey's exclusive territorial waters (0-3 miles). Differentiating the exclusive waters from those shared with foreign vessels within the ICES rectangles gave six sampling zones. For each sampling zone a sampling area was defined based on VMS dredge fishing records, known suitable habitats and fisher advice. Within each reduced fishable area seven sample points were randomly generated using QGIS (Figure 22). This was done with the aim of providing five usable sample points per sampling area resulting in a total of 30 randomised samples. In addition to these, four fixed point samples, based on the 2021 survey sites. were selected for repeat sampling.

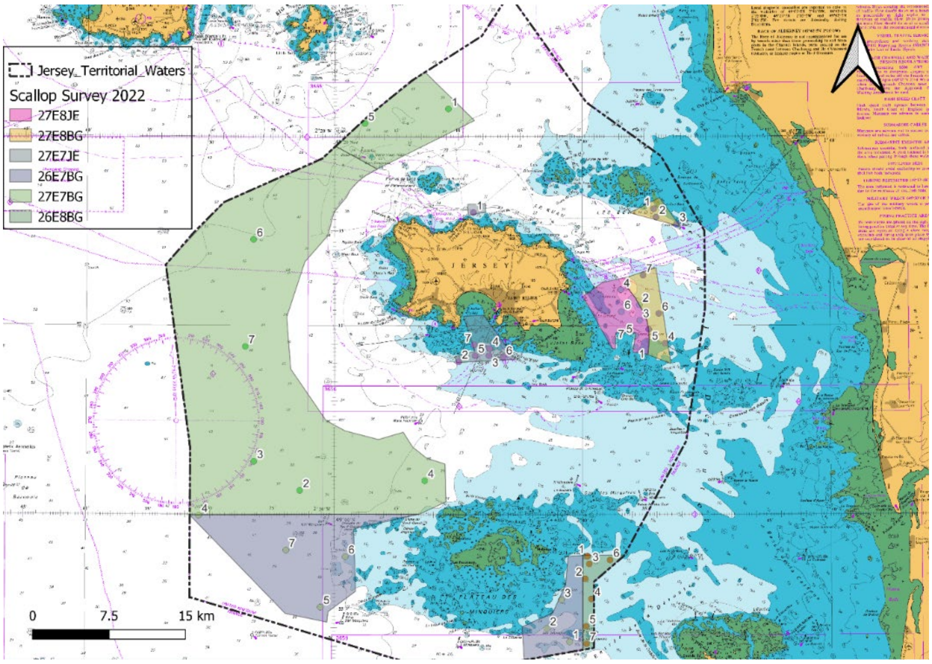
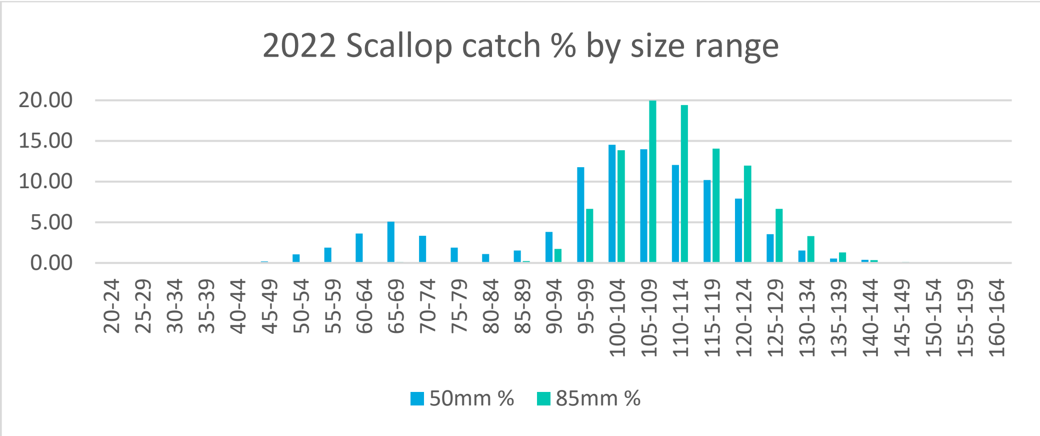


Figure 22 Fishable sampling areas each with seven randomly generated sampling points.

The sampling method was the same as that used in 2021 (See WG Scallop 2021 report) and again stemmed from the method used by Normandy (France) to survey king scallops. Catch rates were higher than in 2021 and followed a similar double bell curve for juvenile (two-year-old) and mature (three years+) scallops. Overall catch was higher despite less sites being sampled but the proportion and total catch of two-year-old shells was smaller indicating a potential lower harvest ahead for the 2023/2024 season (Figure 21).



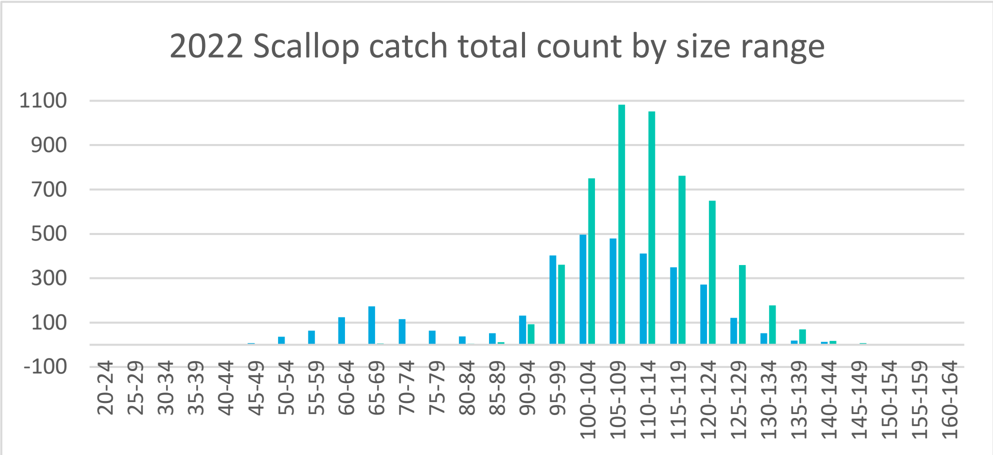


Figure 23 2022 scallop catch by proportion (top) and total weight (bottom).

Dredge bag filling was higher than in 2021, especially for the 50 mm belly ring dredges (Figure 24). This is likely due to the randomised fishing which took place more often on low quality ground than in 2021 when sample points were fisher driven.

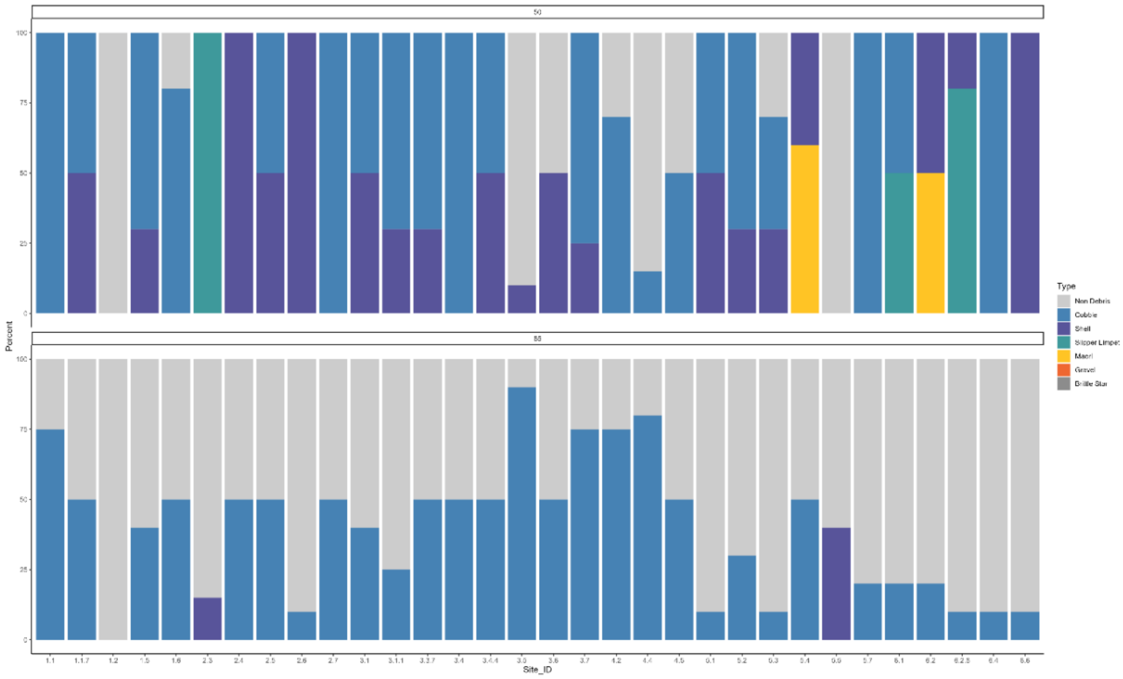


Figure 24 Dredge inert material % fill.

A formal and ongoing analysis of the stock status will be carried out using standard stock modelling tools from 2024 onwards, once a three-year dataset is available.

4.12 France, Bay of Seine. King scallop (*Pecten maximus*)

In France, king scallop fishing is a seasonal activity, authorized by the French Government from 1st of October to 15th of May of the following year, throughout the French territory and for all the fleets concerned. The last fishing season, 2021–2022, was the best observed since the origin of the fishery, with 38,800 tons landed, an increase of 9% compared to the previous season (which was already the best season ever recorded with 35 800 tonnes landed). The king scallop is now the leading species, in terms of tonnage and value, in the French fisheries. French vessels caught 24 600 tonnes (63%) in the Eastern Channel (ICES area 7d), of which almost 70% come from the Bay of Seine alone (ICES statistical rectangles 27E9 and 28E9), which is the heart of the king scallop seabed.

Ifremer leads an annual stock assessment survey in the extended Bay of Seine area, located between the French coast in the south and parallel 49°48 in the north (Figure 25). This area is divided into two parts, a northern part called "Extérieur baie de Seine" from the limit of French territorial waters (12 nautical miles) to parallel 49°48N and a southern part called "Baie de Seine" corresponding to French territorial waters (from the coast to the 12 nautical miles limit).

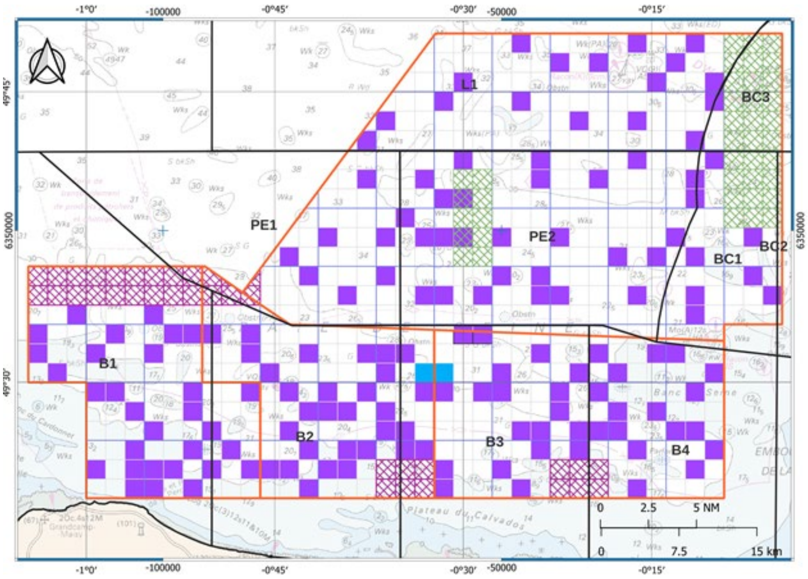


Figure 25 COMOR scientific survey area.

The scientific survey follows a stratified random sampling plan. It has been standardized (protocol, equipment, data) since 1992.

In the area "Extérieur baie de Seine", the 2022 abundance indices are increasing for two-year-old scallops (recruitment) and those aged three years and over (age classes already exploited in previous fishing seasons). The abundance index for one-year-olds (prerecruitment), on the other hand, has fallen sharply (Figure 26).

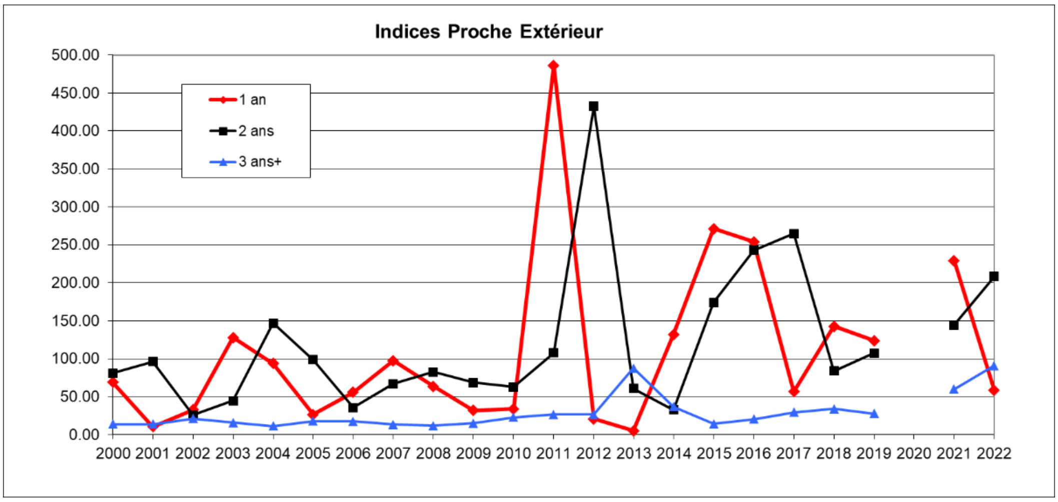


Figure 26 Evolution of abundance indices by year class in the area "Extérieur Baie de Seine".

The exploitable biomass (when all individuals of age two and over have reached the minimum catch size of 11 cm) is thus estimated to have sharply increased from 2021 (Figure 27): 20 024 tonnes compared with 13 645 tonnes, an increase of 46%). This is the second highest biomass estimate for the entire historical series.

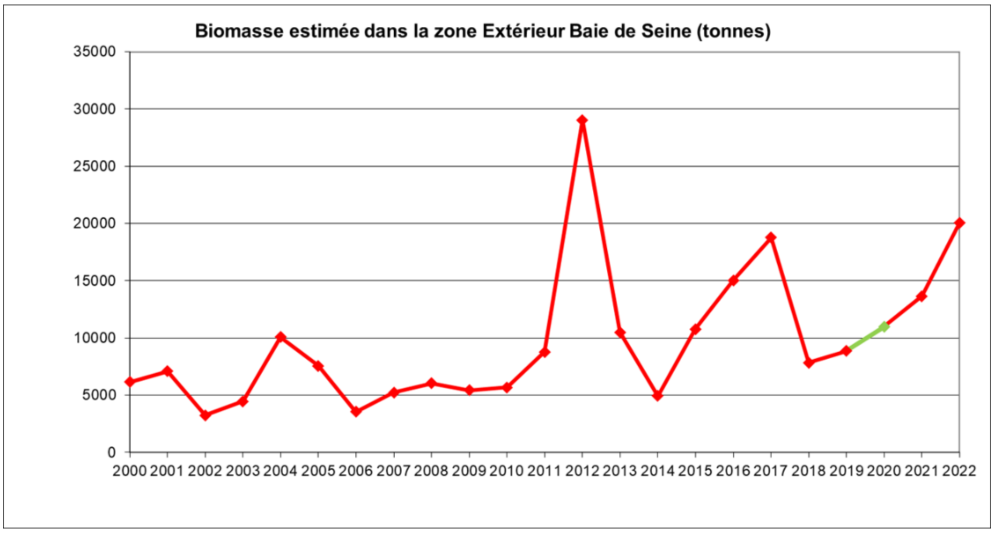


Figure 27 Evolution of exploitable biomass in the area "Extérieur baie de Seine".

In the Bay of Seine, the abundance index of two-year-old scallops is very high, at the same level as the values for 2017, 2018 and 2021. This is the third highest biomass in the historical series. The abundance index for three-year-olds and older is historically the highest ever and increased sharply from 2021 (almost double, +95%). The juvenile abundance index is slightly lower than observed in the last two years but remains at a high level (Figure 28).

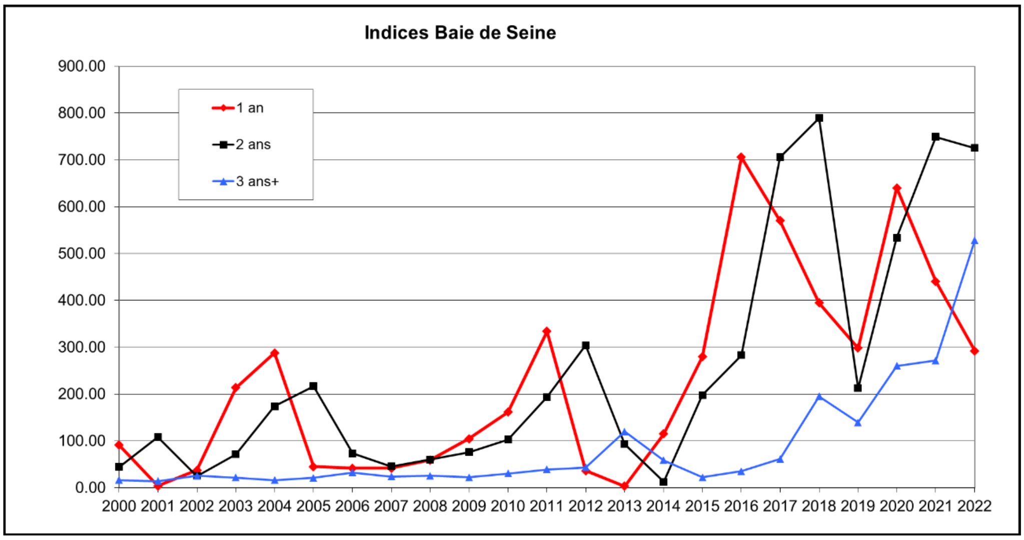


Figure 28 Evolution of abundance indices by year class in the area "Baie de Seine".

As a result, the total exploitable biomass is at its highest level in the history of the fishery, which started more than 50 years ago, at 85 581 tonnes (Figure 29). The stock is in good ecological condition. The population structure between the different age classes is well balanced (Figure 30), and this makes it possible to envisage sustainable commercial exploitation, provided that the environmental conditions remain favourable and that the fishing effort remains stabilized at the current level.

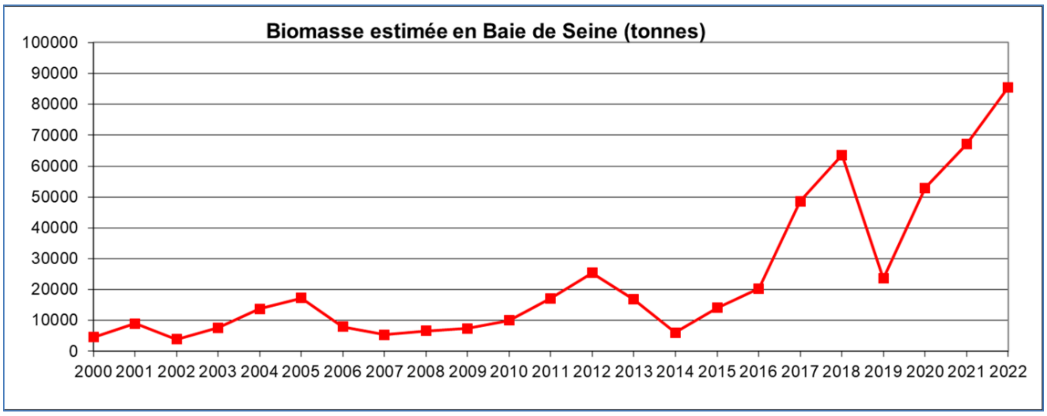


Figure 29 Evolution of exploitable biomass in the Bay of Seine.

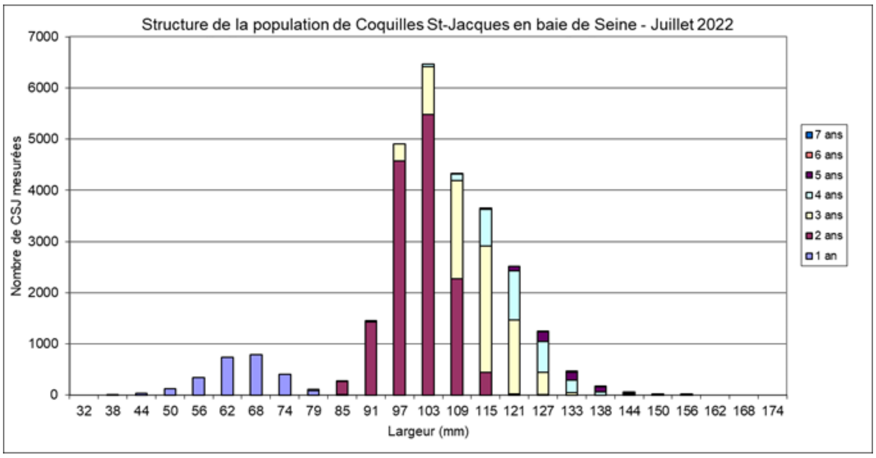


Figure 30 Population structure in the Bay of Seine.

However, in the two areas "Baie de Seine" and "Extérieur baie de Seine", a growth deficit has been observed for all age classes except juveniles (Figure 31). Several hypotheses can be put forward to explain this delay in growth (density/dependence effect, low rainfall during summer 2022, therefore a lower input of mineral salts of terrigenous origin resulting in limited primary production), but without any scientific certainty.

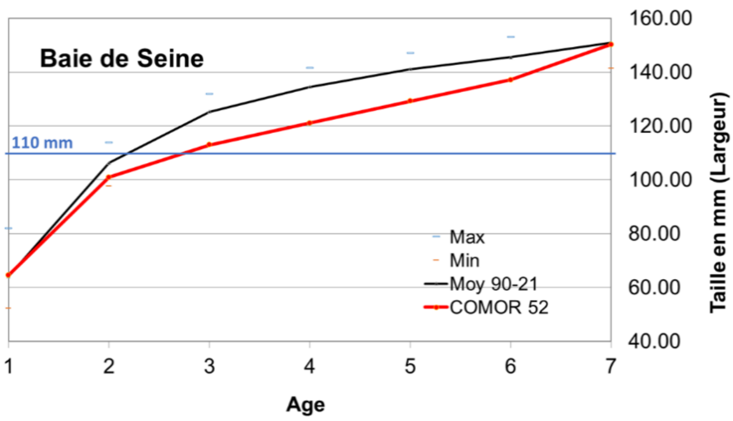


Figure 31 Growth curve estimated in July 2022 for King scallop in the Bay of Seine.

Finally, the total exploitable biomass in the two zones exceeds 100 000 tonnes for the first time (105 625 tonnes), a large increase compared to 2021 (+31%) (Figure 32).

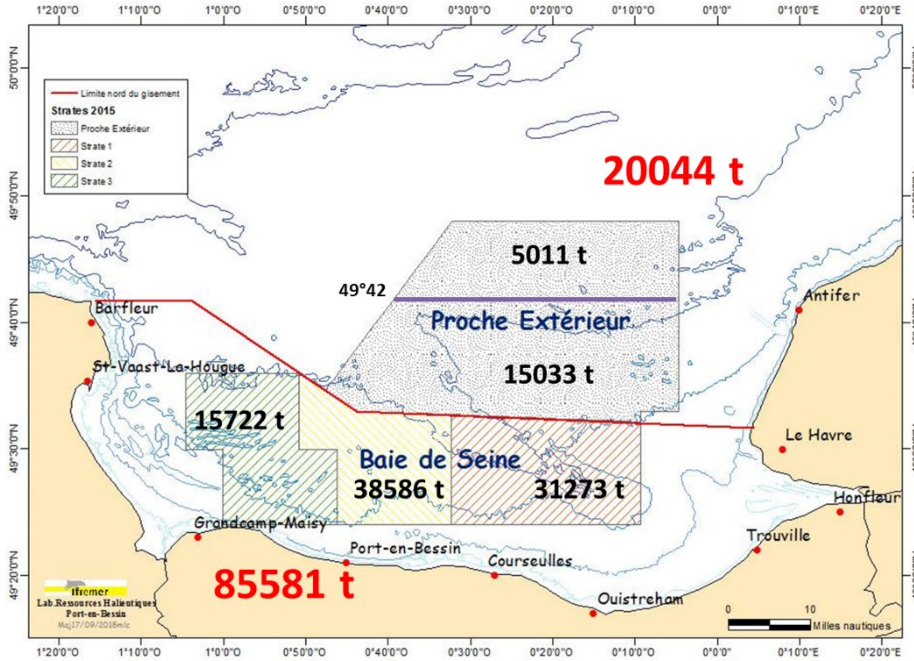


Figure 32 Exploitable biomass distribution per area in 2022.

The scallop distribution on the seabed is relatively homogeneous in all areas of the Bay of Seine. On the other hand, yearling juveniles are mainly found in the western part of the Bay of Seine (Figure 33), which was proposed to the commercial fishing organisations (and accepted) as an area to be closed for fishing in 2022.

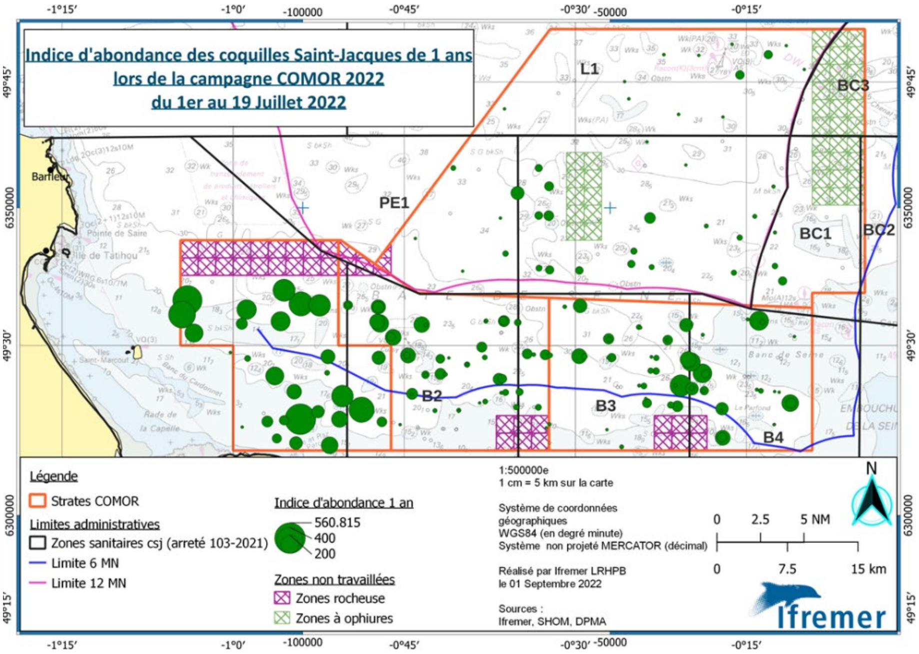


Figure 33 Geographical distribution of one-year-old juveniles in 2022.

4.13 Rotational harvest closure effects on the Bay of Seine king scallop (*Pecten maximus*) stock dynamics

In French territorial waters, the Bay of Seine is divided into five administrative zones, which have been set up for the monitoring of king scallops (in particular monitoring the presence of toxins produced during harmful algae blooms). Since the end of 2016, these areas have also been used for the implementation of a rotational closure system. One of these areas is selected each year by the French fisher's organisations to remain closed to fishing for the entire fishing season. The closed area corresponds to the one where juvenile densities identified during summer stock assessment survey are the highest. This area will not be reopened to fishing until the following season, when another area will be closed (Figure 34).

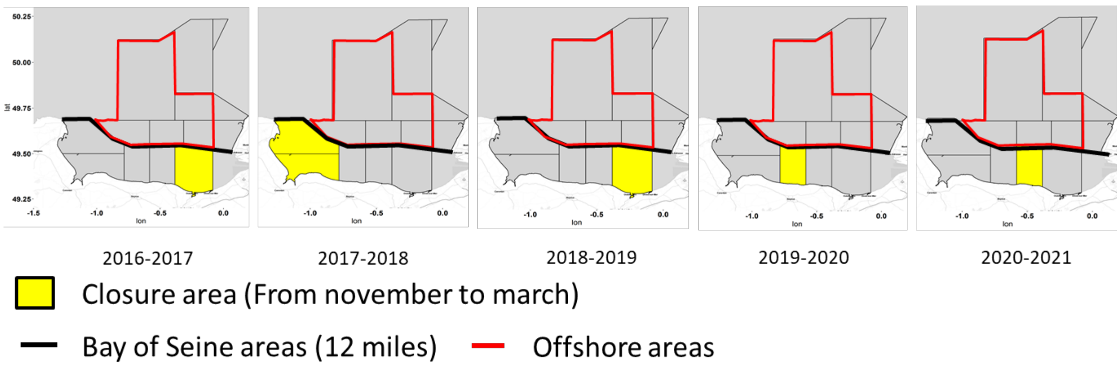


Figure 34 Succession of areas closed to king scallop fishing under the rotational closure system implemented in Bay of Seine (since 28 November 2016).

However, since 2016, there has been a very strong increase trend in the exploitable biomass (Figure 35). Has the implementation of this rotational closure had a positive impact on the scallop population, and if so, can the observed protection be mitigated by changes in the distribution of fishing effort?

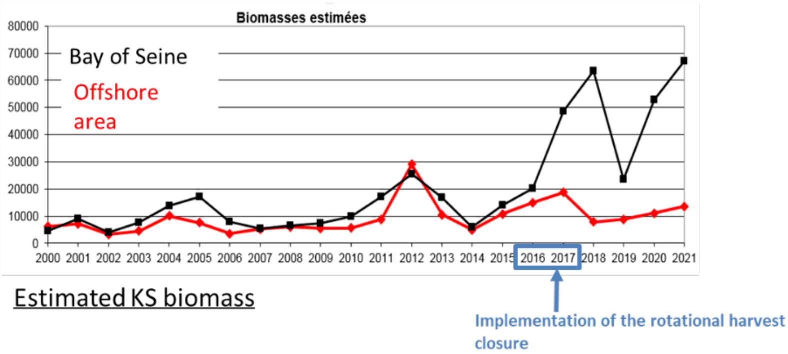


Figure 35 Evolution of the estimated exploitable biomass (in tonnes) in the Bay of Seine from 2000 to 2021.

Data collected during summer scallop stock assessment surveys in the Bay of Seine, as well as catch and effort data (VMS data) from the French fishery during the opening period (October to May of the following year) are used. Based on these data, a generalized linear model (GLM) was developed to measure the effect of closure on the abundance of king scallops by year class, both in the year following the closure and in the longer term after the reopening of the closed area. The evolution of the distribution of fishing effort between the period before the closure system period (before 2016) and after (2016–2021) was also analysed.

It was shown that the closure had an immediate effect on scallop abundance from the moment it was implemented, particularly on individuals aged 2\two years and older (Figure 34).

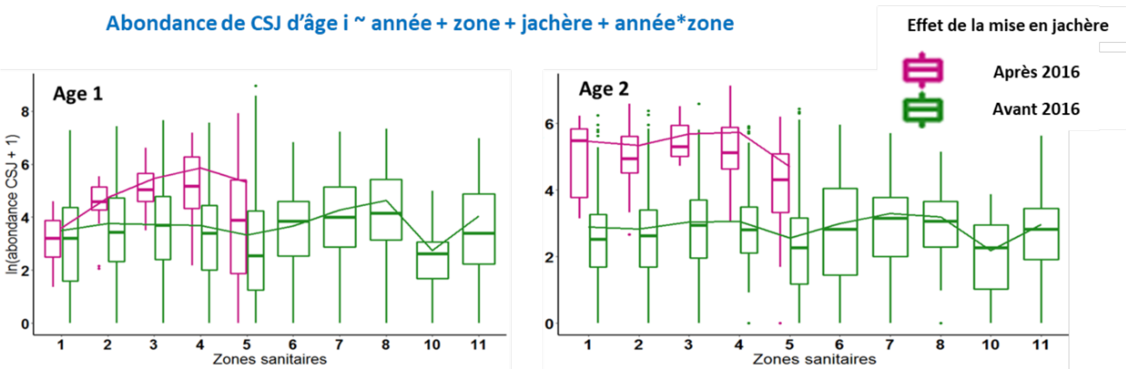


Figure 36 Average abundance by zones for age 1 and 2 in Bay of Seine, before and after 2016.

It was also shown that one year after its reopening, the closure system had a longer term effect, particularly on one-year-old juveniles, but also on already exploited adults aged two years and more. These different effects of closure could be explained by the impact that the closure could have on the different stages of the scallop life cycle in the Bay of Seine.

The distribution of fishing effort was relatively homogeneous between 11 areas prior to 2016 and the introduction of the closure system (areas 1–5 in French territorial waters and areas 6–11 further offshore outside the Bay of Seine). Nevertheless, area three located in the central western part of the Bay and representing the heart of the king scallop seabed had the highest median fishing effort. This fishing effort could be relatively heterogeneous from one year to the next, although at the end of the period between 2013 and 2016 very similar levels were observed both inside and outside the Bay of Seine.

After 2016, the distribution of fishing effort has changed substantially, both seasonally and between areas (Figure 37). Fishing effort is almost zero in the closed area. This same area is favoured when it is reopened, to the detriment of the others. The offshore areas outside the bay are much less exploited than before. The fishing effort in the areas that were not closed becomes median. Before the closure period, fishers exploited the whole of the Bay of Seine in similar proportions both inside and outside the Bay, and in the same way seasonally. With the introduction of the closure system, significant differences appeared between areas within the same season. Finally, the introduction of the closure system allowed the increase of local scallop densities. The effort deployed to achieve the same level of catch has therefore fallen overall.

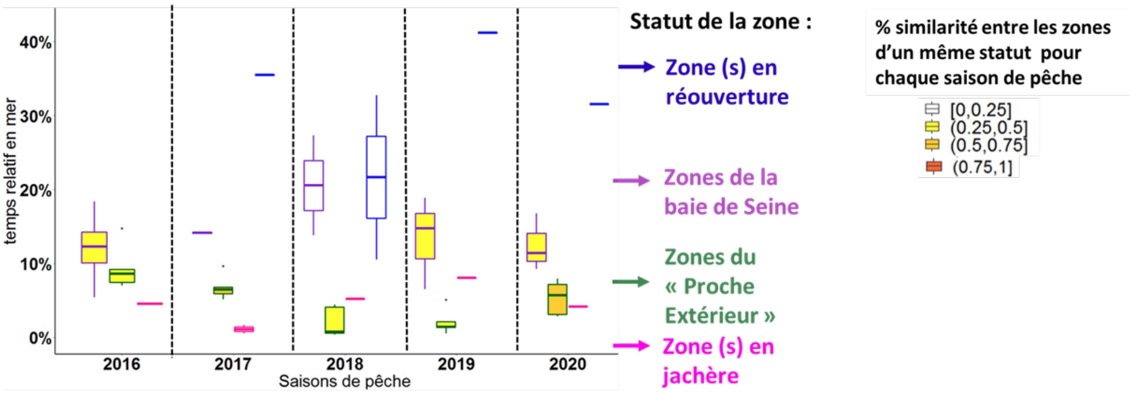


Figure 37 Average fishing effort per year after the introduction of the rotational closure system in 2016.

5 ToR E Continue to refine stock structure using best available information on genetics and larval dispersal and improve current mapping of scallop stocks. Establish links with WGOOFE to collaborate on specific work areas.

An essential prerequisite of sustainable fisheries is matching biologically relevant processes to management actions. However, fisheries assessments are often hampered by limited knowledge of key biological processes, particularly isolating complex stock structures within management areas. Historically, stock units have been based on geographical landmarks and socio-economic boundaries. However, science has highlighted that populations structures, which form the basis of stock units, are far more dynamic and complex.

The Stock Identification Methods Working Group (SIMWG) reviews new methods for the definition and investigation of stock structure and provides recommendations to other ICES expert groups on how to interpret patterns of population structure (ICES SIMWG 2022). There is a diverse array of tools utilized to assess probable stock structures such as genetics/genomics, parasitology, otolith microchemistry, morphology, tagging and statistical modelling. Given the variety of methods used to delineate stock structures, SIMWG includes experts from each of these scientific fields working together to aggregate the evidence into coherent advice (ICES SIMWG 2022). Requests for assistance from SIMWG can be made in accordance with the ICES chair guidance (section 3.8) from Stock Coordinators, Working Group and Workshop chairs or via ICES Secretariat.

Recently, members of SIMWG have assisted with Stock Identification of North Sea Cod (WKNS-CodID 2020), Stock Identification of West of Scotland Sea Cod (WK6aCodID 2021), and a benchmark workshop on identifying stock structures for selected elasmobranch stocks (WKELASMO 2021, unpublished). In 2022, the group reviewed and discussed stock structures of hake and anglerfish stocks by request of the Working Group for the Bay of Biscay and the Iberian Waters Ecoregion (WGBIE) and the structures of anchovy by request of the Working Group on Southern Horse Mackerel, Anchovy, and Sardine (WGHANSA) (ICES SIMWG 2022).

Increasingly, genomic evidence is being given more weight during stock identification discussions. As the cost of these techniques continues to decrease, collaborations between fisheries industries and genomic sequencing centres are providing the tools necessary to sequence the genomes of invertebrate and vertebrate species across the Northeast Atlantic. Assembling the genomes of species is the first step towards identifying a comprehensive suite of regionally specific population markers to assess population boundaries. Initiatives, such as the Darwin Tree of Life (DToL) and European Reference Genome Atlas (ERGA) are working to sequence the genomes of every eukaryotic organism within marine and freshwater environments. Within the UK and Ireland, DToL provide a variety of services, from supplying sampling equipment, to organising cold-chain shipment of samples. DToL has a highly functional sequencing pipeline which enables open access to the end result: a fully assembled and annotated genome all free of charge. Moving forward SIMWG expects more evidence of stock structures to be provided via genomic studies, so it is recommended to engage with these initiatives as early as possible.

Further mapping work has been completed as part of PhD analyses investigating the relationship between relative benthic status and scallop dredging in UK waters, and on the impact of scallop dredging on vulnerable marine ecosystems. The main aspect of this work is a review paper on scallop fishery management measures worldwide. This work is specifically focused on the impact of scallop fisheries on seabed habitats but could be used further for other aspects of scallop fishery management if useful.

5.1 Scallop dispersal modelling in the English Channel

This study examined the transport of king scallop larvae within the English Channel and determined the potential for larvae hatched in different geographical units to settle in other areas. It was developed to resolve two specific aims: i) describe the flow of larvae between fishing grounds in the English Channel ii) assess the contribution of un-dredged scallop grounds to the larval supply of dredged grounds.

Larval transport in the ocean was simulated using high resolution hydrodynamic modelling, which realistically simulated the combinations of flows due to the tides, winds, riverine discharge and density structure to produce velocity fields. These velocity fields were then combined with information about the likely life cycle of scallops (e.g. spawning times and larval behaviour), in a particle tracking model. The harvestable biomass of each ground was used to weight the amount of spawning produced. The particle tracking model results were interpreted with maps of scallop extraction grounds to estimate the magnitude of the connection or isolation between the sites (Figure 38).

A high-level interpretation of the results showed that the Western and Eastern channel stocks were relatively isolated. It was possible to consider each area in detail and provide a larval flow matrix between areas and classify those which have high retention and high resilience, medium resilience, and those areas which were high input from other areas, and areas where neither condition applies.

There were three grounds that were likely to receive significant larvae from un-dredged beds. In the Western Channel, bed 7.e.3 received 22% from TV.7.e.B while 7.e.6 receives 41% from TV.7.e.C. In the Celtic Sea, 7.f.1 received 78% of the larvae from TV.7.e.A. The remaining eight assessed beds in the UK have contributions from un-dredged beds of 13% or less. It would be useful to put these larvae flows and connections into a population/management strategy evaluation model to explore the risks and benefits of different approaches to considering un-dredged biomass in management decisions.

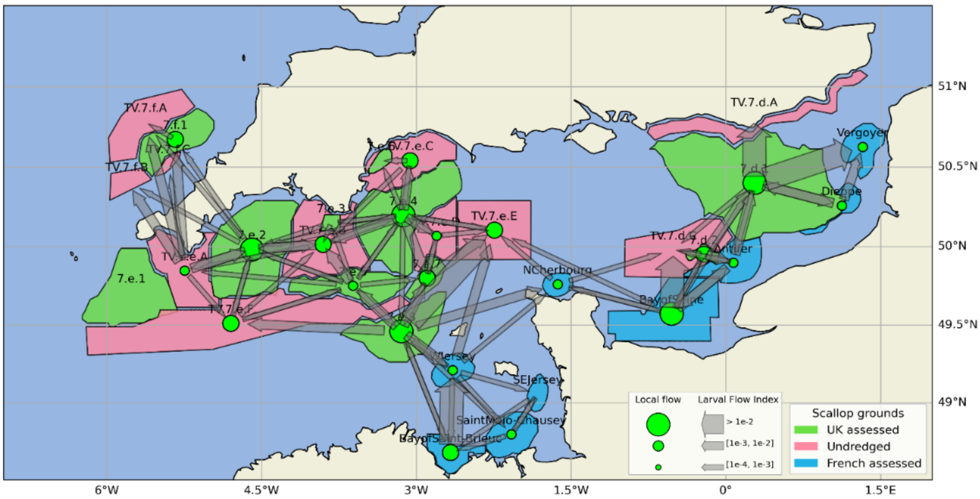


Figure 38 Larval flows between UK dredged and un-dredged regions as defined in Cefas stock assessment reports (Lawler and Nawri, 2022) and areas in areas defined by Nicolle *et al.* (2017).

The WG received an update on the progress of the PhD project which focuses on understanding genetic structure and connectivity among *P. maximus* populations around Scottish waters to better identify management units and is currently being carried out at the Heriot-Watt University. This project is part of the Project UK Fisheries Improvements (PUKFI), a collaborative stakeholder partnership initiative with the Marine Stewardship Council that aims to improve the environmental sustainability of selected UK fisheries. Briefly, in the first year of the project, relevant and distinct scallop grounds were identified through VMS data and consultations with Marine Scotland Science (MSS) and fishery industries. Also, tissues for genetic analysis have been collected from individuals of *P. maximus* sampled during the MSS Survey in the Clyde Sea (October 2019) and on the northeast coast of Scotland (July 2022). Currently, a subset of samples is being analysed to infer the level of spatio-temporal resolution of genetic markers. This will provide useful information in refining the number of samples that will be analysed for the project, maximizing the information retrieved at different spatial scales.

The group also received an update on the mathematical modelling of *P. maximus* which is underway at the University of Strathclyde as part of a PhD project. During the last year the focus has mostly been on identifying patterns of larval dispersal. Thanks to additional funding awarded to the PhD student under the Scotia-Canadian Research Exchange grant by the Marine Alliance for Science and Technology for Scotland (MASTS) and the Ocean Fisheries Institute (OFI) in Canada, the PhD student established an ongoing collaboration with the University of Dalhousie to adapt an existing modelling framework currently in use for *P. magellanicus* in Nova Scotia to *P. maximus* in Scotland. Over summer the student explored different particle tracking models for larvae, to identify suitable models to be used for *P. maximus* in Scotland with available hydrodynamic forcing data. One of the two trackers was coded in Ocean Parcels, a recently developed Python toolbox which offers great flexibility and a lightweight structure compared with the Finite Volume Coastal Ocean Model (FVCOM) standard tracker. The drawback of this is that it is only available for use with NEMO based fields, which are less resolved than FVCOM outputs for hydrodynamic forcing. Another, more sophisticated tracker was used with FVCOM outputs from the Scottish Shelf Model from Marine Scotland Science. The analysis of outputs from these is currently ongoing.

Additionally, a habitat investigation to establish initial conditions for the particle tracker was performed as part of the project. The aim was to use environmental data to predict the presence of scallops around Scotland. Attempts were made to generate predictive maps by means of random forests, a supervised machine learning algorithm. Survey data supplied by MSS was interpolated on sediment datasets available as supplementary materials to Wilson *et al*. (2018), and then used to train the algorithm. Further statistical investigation revealed that the spatial resolution of the data might be too coarse, and as such a decision to look at more detailed VMS data were taken. The PhD student continues to work in collaboration with both Marine Scotland and researchers from around the globe to identify realistic patterns of scallop larval dispersal in Scottish water under different environmental forcing. The outcome of this investigation will be helpful in assessing which beds contribute to recruitment the most, as well as the effects of planned spatial closures on stocks.

6 ToR F Review current biological parameters and update when more information becomes available and report on all relevant aspects of: biology, ecology, physiology and behaviour, in field and laboratory studies

The review paper, "A global review of catch efficiencies of towed fishing gears targeting scallops" has been published in Reviews in Fisheries Science and Aquaculture (A Global Review of Catch Efficiencies of Towed Fishing Gears Targeting Scallops). (Delargy *et al*., 2022).

The abstract

"The catch efficiency of towed fishing gears is the fraction of the target species in the gear path that were caught and retained. Catch efficiency is fundamental for calculating population status required for establishing fisheries management reference points. Consequently, catch efficiency has been estimated for many commercially important scallop (Pectinid) fisheries. This article synthesizes and discusses estimates of catch efficiency of towed gears used to target scallops, the methods for estimating catch efficiency and the factors that influence these estimates. There exists considerable variation in catch efficiency estimates among studies (0.1 to 0.7), and it is important that this variation is accounted for during surveys and stock assessments to avoid erroneous advice and estimates. The high variation was driven by differences in experimental conditions, estimation methods and scallop behaviour.

Scallop size and substrate type were the two most common reporting categories discussed in the studies and consequently should be considered the two most important drivers of catch efficiency. Other important factors such as gear specifications, and scallop species were featured in some studies. This review will be highly useful for designing catch efficiency experiments, survey design and stock assessments by understanding, and accounting for, catch efficiency variation."

6.1 Growth of Pecten maximus – issues with determining height-at-age and connections to environmental conditions

Cefas (Lowestoft, England) presented preliminary results from their ageing programme of *P. maximus* based on shells from annual dredge surveys in the English Channel and the western North Sea (Figure 14).

The two topics discussed addressed direct and indirect effects of water temperature on scallop growth. Direct effects are short-term and experienced by individual animals on a seasonal basis, as their growth rate fluctuates between winter and summer. Indirect effects modify average growth rates of an entire population over evolutionary time-scales, through their influence on genetics. Unlike the local temporal fluctuations from direct effects, indirect effects can potentially lead to a spatial differentiation between populations.

Normally, Cefas dredge surveys in the eastern English Channel and the western North Sea are conducted in September, and in the western English Channel in May. However, in 2020, due to the Covid-19 pandemic, the western survey was delayed until August. This allows a comparison between the growth since the last cold season an animal lived through until it was caught in either May or August (Figures 39 and 40). For the animals caught in May, the edge width varies between 0–2 mm, depending on age during the final winter. This indicates that, after the cold season, growth in the western English Channel resumes in late April or early May. By August, age-3 scallops have grown by more than 10 mm, and age-2 scallops by more than 25 mm, while ages 5 and older have grown by less than 5 mm. If terminal height is used to calculate size-at-age relationships, it is therefore essential to relate them to decimal ages (e.g. by counting months from the start of the growth season). Otherwise, the growth rate implied by the terminal height-at-age relationship varies over the course of the growth season, as younger animals grow faster than older ones, and the height-at-age curve progressively flattens. Generally, annuli provide more precise markers than terminal height, to establish the size of an animal at a particular time of the year. Also, when using annuli to determine growth rates, more than one height-at-age can be derived per shell, requiring the collection of fewer animals to build up a large sample.

Figure 39 Flat (upper) valve of *P. maximus* caught in the western English Channel, showing growth check rings (annuli) laid down during the second and third cold season this pictured animal lived through, and the growth it underwent since the last cold season until it was caught.

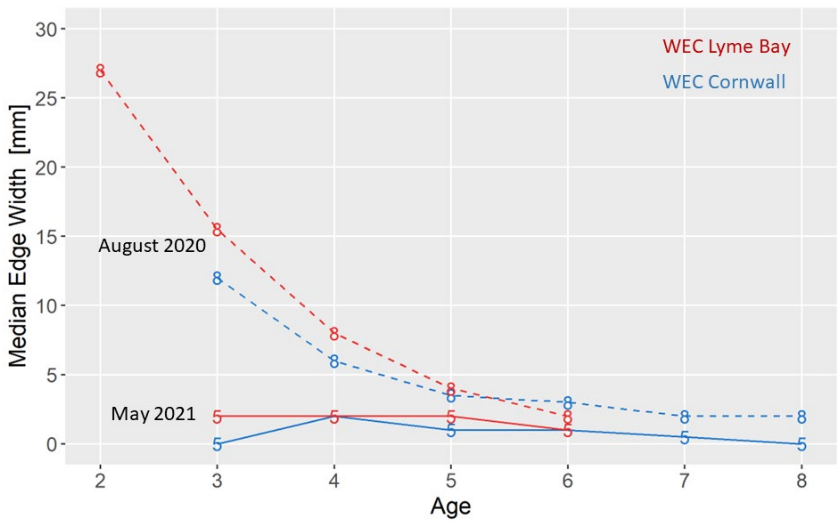


Figure 40 Median edge widths (growth from last annulus until capture) for shells caught in the western English Channel (south of Cornwall in blue, Lyme Bay in red) in August 2020 (dashed lines, labelled "8") and May 2021 (solid lines, labelled "5").

Using data from the Northwest Shelf Ocean Physical and Biogeochemical Reanalysis from the Copernicus Marine Environment Monitoring Service (CMEMS), the environmental conditions in different assessment areas can be characterized, such as the proportion of days per month during which the water temperature at the seabed is within certain ranges that are associated with certain growth behaviours. Based on studies with cultivated *P. maximus* in UK waters, the ideal temperature range for growth is 10–17^{0}C (Laing, 2002). A switch from winter to summer metabolism occurs at around 10^{0}C, and growth ceases below 6.5^{0}C. A comparison between the North Sea assessment area along the Yorkshire coast (Area 27.4.b.S) and the assessment area in the eastern English Channel (Area 27.7.d.N) shows that there is a clear difference in seabed temperature, with an earlier start and later end of the season with ideal growing conditions in the English Channel (Figure 41). In the North Sea area, temperatures suggest that growth might stop completely in March. Conversely, in the southern area, temperatures in August and September routinely exceed the ideal range, which might cause reduced growth due to stress.

In addition to temperature, there are several other environmental factors that influence growth rates on seasonal and evolutionary time-scales, including salinity and phytoplankton concentration (Laing, 2002). Non-lethal trauma, such as impact shocks from interactions with dredges, can also lead to temporary growth checks.

Despite these factors, there is the possibility that the difference in seabed temperature contributes to an evolutionary differentiation of scallop growth rates in the North Sea and English Channel assessment areas. The main distinction between these two areas is a different age-related pattern of growth rate, with fast early growth and slow late growth in the English Channel, compared with the intermediate growth within the same age range in the North Sea (Figure 40). Lifetime average growth rates, or the terminal sizes of old animals, are similar between the two assessment areas. The higher temperatures in the English Channel, if they have any effect on evolution, therefore appear to favour fast growth until about age two. From then onwards, limiting factors appear to come into play that favour reduced growth rates relative to those in the North Sea.

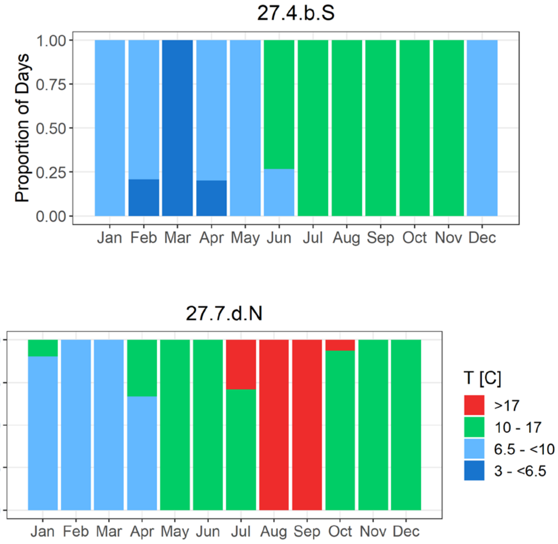


Figure 41 Proportion of days per month during which the water temperature at the seabed in the western North Sea assessment area (top 27.4.b.S) and the eastern English Channel assessment area (bottom 27.7.d.N) is within the indicated ranges.

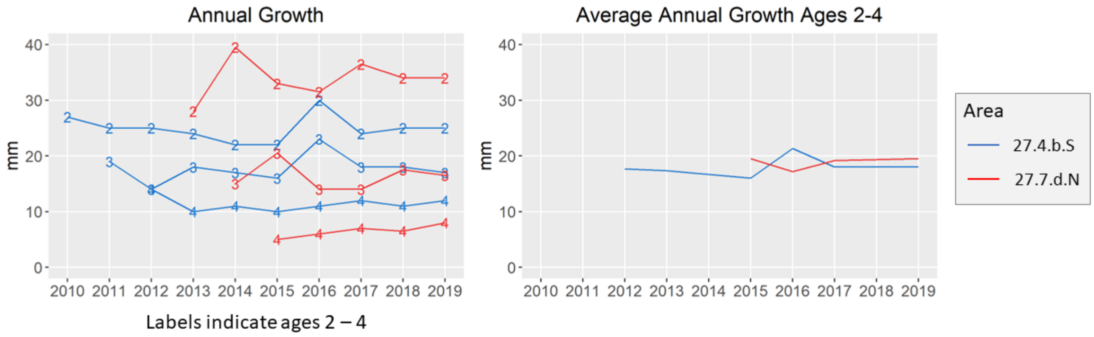


Figure 42 Annual growth (annuli increments) in the western North Sea assessment area (27.4.b.S, blue lines) and the eastern English Channel assessment area (27.7.d.N, red lines) for ages 2–4.

6.2 Scallop potting with lights: A novel, low impact method for catching European king scallop (*Pecten maximus*)

The new discovery that scallops can be attracted into static fishing gear using LED lights was presented to the WG. This novel finding presents an opportunity for the development of a new, low impact fishing method for scallops. In this study, the potential for scallops to be fished using illuminated standard commercial crustacean pots was investigated. In the first phase of the research, the effect of using light in a range of pot designs on scallop, brown crab, lobster and crawfish, and spider crab catches was assessed in Cornwall between December 2020 and February 2021. A total of 77 strings were shot, deploying 1886 pots of six treatment types. The fishing grounds used in the trial are traditionally potted for crustacea and are not renowned scallop beds. Despite this, all treatments with lights retained scallops and of the 518 scallops recorded, 99.6% (n = 516) were caught in pots with lights. A modified parlour pot with lights caught scallops most effectively, with a maximum catch rate of 19 scallops per string (23–24 pots per string) and the maximum number of scallops recorded in a single pot was 24. It was therefore shown that simple and inexpensive modifications to existing crustacean pots present fishers the opportunity to augment their existing crustacean catches with a low environmental impact, premium scallop product. This first phase of the project was published in August 2022 (*Enever et al., 2022*) and received high amounts of media attention and interest from the commercial fishing industry. In the second phase of this project, conducted during summer 2022, it was established that scallops are most strongly attracted to blue lights. Further field trials done in collaboration with fishers around the UK are examining the effectiveness of different trap designs. Results to date have found high levels of spatial variation in scallop catch rates and a possible small negative effect on lobster catches, but no effect on crab catches. Scallops caught using lights have started to appear in restaurants. The next phase of the project will aim to further expand on this commercial potential.

6.3 Recovery of commercially valuable scallop (*Pecten maximus*) populations under different forms of protection around the Isle of Arran, Scotland

The WG were also presented with the latest results from a study assessing the effects of a Marine Protected Area (MPA) and No-Take Zone (NTZ) around the Isle of Arran, Scotland, on the population dynamics and structure of commercially valuable king scallops (*Pecten maximus*). This research built on previous data collected by annual dive surveys from 2010–2015 and in 2019. Now, fourteen years after the NTZ was implemented in 2008, and six years since the MPA was implemented in 2016, new data were collected in 2022 to compare the differences in densities and population structure. Fifty-eight underwater SCUBA survey transects were completed within the NTZ, the MPA and in a fished area open to scallop dredging. All scallops were counted on each transect, the first ten were aged and measured, and a subsample were collected for dissection to assess exploitable and reproductive biomass. King scallop density was over twice as high in the NTZ (21.8 scallops/100m^2) and Far Control area in the south of the MPA (22.8/scallops/100 m^2) than in the Dredged area (10.7/100 m^2). In the Near Control area around the NTZ, which was open to dredging until 2016, the density was almost 50 scallops/100 m^2, dramatically higher than all the other sites. Across the South Arran MPA overall, mean scallop density was 10 times higher than during baseline surveys conducted in 2014 and 2015, prior to protection from dredging. Settlement of juvenile scallops was highest in the NTZ and Near Control areas and significantly associated with the presence of kelp and macroalgae. With increasing levels of protection, scallops were also significantly older and larger in terms of shell length, total biomass, and reproductive biomass. Given the higher reproductive potential per unit area in the protected zones, these scallops are likely to be exporting high levels of larvae to surrounding areas. These results therefore suggest that protected areas can be a key tool for implementing ecosystem-based fisheries management.

7 ToR G Compare age reading methodologies and develop common practices and determine precision and bias of scallop age reading data derived from different readers.

The WG were presented an overview of the WKSA, including previous outcomes from the first ICES Workshop on Scallop Aging held in October 2021. An overview of the ToR's was displayed and key points were highlighted. An update on the planned upcoming in-person workshop was provided, which has been rescheduled for February 2023 at Cefas in Lowestoft. The outcomes of this workshop include aging by microscope, production of reference sets, to run a new SmartDots session across the readers and review and complete an ICES TIMES document on aging methodologies. Lastly, an overview of SmartDots was provided as there will be an updated SmartDots event at the upcoming workshop. Further details on the upcoming workshop will follow in due course.

8 ToR H Identify, list and collate all available data for queen scallops and agree on appropriate stock assessment areas. Share knowledge, draft a review paper and attempt stock assessments where possible.

Queen scallop research, monitoring and stock assessment have often been considered a lower priority in most regions outside the Irish Sea. The queen scallop subgroup was formed following recommendations at the 2020 WG meeting, with the primary aim of focusing attention on these fisheries (mainly, but not exclusively, *Aequipecten opercularis)*.

The subgroup proposed to identify and define assessment areas, collate available data, determine data gaps and how best to fill them, and carry out stock assessments where appropriate. Progress was made in 2020 and early in 2021 but members had insufficient resources to make further progress and a meeting scheduled for June 2021 was postponed indefinitely. Landings and effort data have been collated (Table 7; Figure 43) but note that data for the Isle of man are not available before 2011. Queen scallop landings have shown a decline since 2011 (26 663 tonnes) and were reported as 5390 tonnes in 2021 (Table 7).

Targeted and non-targeted queen scallop surveys are carried out in the Irish Sea and around Scottish coasts by Bangor University (for Isle of Man and Welsh Government), AFBI and Marine Scotland. Enhanced sampling on Cefas (England) annual trawl surveys and collection of samples for the Bangor project to investigate spatial variability of size and age structure around the UK is ongoing.

The subgroup is yet to determine which stocks warrant assessment and what data gaps exist for recommendation to the WG. The feasibility of filling any data gaps and the requirement for expansion of current monitoring or survey work will rely on funding. A review paper will provide a summary of the current situation, may make recommendations towards further data gathering and describe what might be achieved if this sampling is realized. The WG decided that this initiative should be reinvigorated as soon as possible by reinstating the subgroup meetings.

Table 7 Provisional landings (live weight (including shell), t) of queen scallops for 2000–2022 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.

	ICES Subarea				
Year	**IV**	**VI**	**VII**	**VIII**	**Total**
2000	105.4	2.1	5104.3	19.4	5231.2
2001	159.1	100.3	9625	17.6	9902
2002	61	4688	11437.6	49.1	16235.7
2003	22.8	1253.5	11507	43.2	12826.5
2004	33	1494.4	7140.7	63.5	8731.6

	ICES Subarea				
Year	**IV**	**VI**	**VII**	**VIII**	**Total**
2005	18.5	1284	9028.1	74.4	10405
2006	21.7	1413.4	8971.4	110.7	10517.2
2007	12	80	13123.6	60.1	13275.7
2008	9.2	203.9	5260.8	51.6	5525.5
2009	16.2	1851.2	5607	91.5	7565.9
2010	11.3	2972.3	12691.8	116.3	15791.7
2011	11.1	3002.1	23520.1	130	26663.3
2012	36.4	4927	17335.9	35.4	22334.7
2013	20.9	2041.2	18864.8	25.2	20952.1
2014	8.8	1022.6	11003.3	47.7	12082.4
2015	17.5	90.2	14535.3	75.8	14718.8
2016	1238	136.3	11090.5	175.8	12640.6
2017	141.2	215.8	10480.4	197.6	11035
2018	66.4	75.9	9272.2	134.6	9549.1
2019	34.1	1.8	6170.8	78.5	6285.2
2020	6	0.7	5220.8	14.9	5242.4
2021	5.3	87.9	5265.6	31.6	5390.4

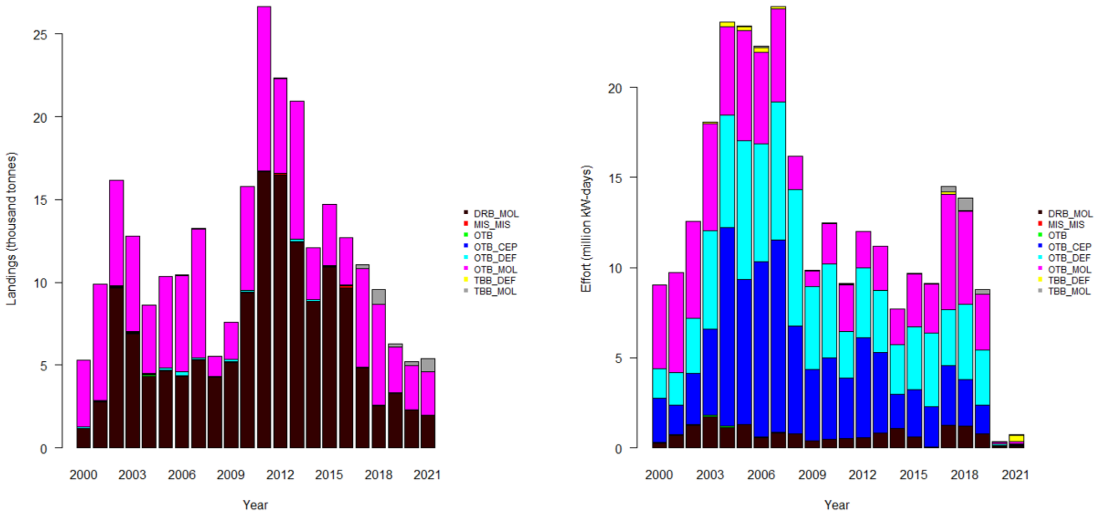


Figure 43 Annual landings (live weight (including shell), thousand tonnes) and associated effort (million KW days) reported for queen scallops. Landings and effort are divided by métier within each year as coloured by the legend. Data for Isle of Man are not included prior to 2011 and Scotland are not included prior to 2002.

References

Delargy, A.J., Blackadder, L., Bloor, I., McMinn, C.,Rudders, D.B., Szostek, C.L. , Dobby, H., Kangas, M., Stewart, B.D., Williams, J.R., Stokesbury, K.D.E (2022). A Global Review of Catch Efficiencies of Towed Fishing Gears Targeting Scallops, Reviews in Fisheries Science & Aquaculture, https://doi.org/10.1080/23308249.2022.2139170

Ester, M., Kriegel, H.P., Sander, J., Xiaowei, X., 1996. A density-based algorithm for discovering clusters in large spatial databases with noise. pp. 635–654. https://doi.org/10.1016/B978-044452701-1.00067-3

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.

Gerritsen, H.D., Minto, C., Lordan, C., 2013. How much of the seabed is impacted by mobile fishing gear? Absolute estimates from Vessel Monitoring System (VMS) point data. ICES J. Mar. Sci. 70, 523–531. https://doi.org/10.1093/icesjms/fst017

Hintzen, N.T., Aarts, G., Rijnsdorp, A.D., 2019. Persistence in the fine-scale distribution and spatial aggregation of fishing. ICES J. Mar. Sci. 76, 1072–1082. https://doi.org/10.1093/icesjms/fsy144

ICES (2020): Workshop on Stock Identification of North Sea Cod (WKNSCodID). ICES Scientific Reports. Report. https://doi.org/10.17895/ices.pub.7499

ICES. 2021. Scallop Assessment Working Group (WGScallop). ICES Scientific Reports. 3:114. 106 pp. https://doi.org/10.17895/ices.pub.9561

ICES (2022): Workshop on stock identification of West of Scotland Sea cod (WK6aCodID; outputs from 2021 meeting). ICES Scientific Reports. Report. https://doi.org/10.17895/ices.pub.10031

ICES (2022): Stock Identification Methods Working Group (SIMWG). ICES Scientific Reports. Report. https://doi.org/10.17895/ices.pub.20937001.v1

Laing, I., 2002: Scallop cultivation in the UK: a guide to site selection, Cefas, Lowestoft, England.

Lawler, A and Nawri, N. 2021. Assessment of Scallop stock status for selected waters around the English Coast 2019/2020, a Defra and Industry Funded Project. Cefas publication. 2022.

Murray, L.G., Hinz, H., Hold, N., Kaiser, M.J., 2013. The effectiveness of using CPUE data derived from Vessel Monitoring Systems and fisheries logbooks to estimate scallop biomass. ICES J. Mar. Sci. 70, 1330–1340. https://doi.org/10.1093/icesjms/fst099

Nicolle, A., Moitie, R., Ogor, J., Dumas, F., Foveau, A., Foucher, E. and Thiebaut, E. Modelling larval dispersal of *Pecten maximus* in the English Channel: a tool for the spatial management of the stocks. ICES Journal of Marine Science, 74(6). 2017.

Thorson, J.T., 2019. Guidance for decisions using the Vector Autoregressive Spatio-Temporal (VAST) package in stock, ecosystem, habitat and climate assessments. Fish. Res. 210, 143–161. https://doi.org/10.1016/j.fishres.2018.10.013

Annex 1: List of participants

Member	Dept/Institute	Country	Email
Adam Delargy	University of Massachusetts Dartmouth	United States	adelargy@umassd.edu
Andy Lawler	Centre for Environment, Fisheries and Aquaculture Science, CEFAS	England, UK	andy.lawler@cefas.co.uk
Bryce Stewart	University of York	England, UK	bryce.stewart@york.ac.uk
Carrie McMinn	Agri-food and Biosciences Institute	Northern Ireland, UK	Carrie.McMinn@afbini.gov.uk
Claire Szostek	Exeter University	England, UK	C.L.Szostek@exeter.ac.uk
Dave Rudders	Virginia Institute of Marine Science	United States	rudders@vims.edu
David Murray	CEFAS	England, UK	david.murray@cefas.gov.uk
Ellen Sofie Grefsrud	Institute of Marine Research	Norway	ellen.sofie.grefsrud@hi.no
Eric Foucher	Ifremer	France	eric.foucher@ifremer.fr
Francis Binney	Government of Jersey	Channel Islands	F.Binney@gov.je
Guillermo Martin	Marine Institute	Ireland	guillermo.martin@marine.ie
Helen Dobby	Marine Laboratory, Marine Scotland Science	Scotland, UK	h.dobby@marlab.ac.uk
Henrik Kjems-Nielsen	ICES	Denmark	henrikkn@ices.dk
Isobel Bloor	University of Plymouth	Isle of Man	i.bloor@bangor.ac.uk
Jessica Harvey	CEFAS	England, UK	jessica.harvey@cefas.gov.uk
Jónas Jónasson	Marine and Freshwater Research Institute	Iceland	jonas.jonasson@hafogvatn.is
Karen Vanstaen	CEFAS	England, UK	karen.vanstaen@cefas.co.uk
Kevin Stokesbury	University of Massachusetts Dartmouth	United States	kstokesbury@umassd.edu
Lynda Blackadder	Marine Science Scotland	Scotland, UK	lynda.blackadder@gov.scot
Mairi Fenton	Heriot Watt	Scotland, UK	mmf13@hw.ac.uk
Natalie Hold	Bangor University	Wales, UK	n.hold@bangor.ac.uk
Nikolai Nawri	CEFAS	England, UK	nikolai.nawri@cefas.co.uk
Oliver Tully	Marine Institute	Ireland	oliver.tully@marine.ie

Rhei Ammaturo	Univeristy of Strathclyde	Scotland, UK	rhei.ammaturo@strath.ac.uk
Samantha Bampleid	Government of Jersey	Channel Islands	s.blampied2@gov.je
Shona Kinnear	Marine Science Scotland	Scotland, UK	shona.kinnear@gov.scot
Simone D'Alessandro	Heriot Watt	Scotland, UK	sd2020@hw.ac.uk
Spyros Fifas	Ifremer	France	spyros.fifas@ifremer.fr
Tiago Silva	CEFAS	England, UK	Tiago.Silva@Cefas.co.uk

Annex 2: Resolution

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

	Meeting dates	Venue	Reporting details	Comments (change in Chair, etc.)
Year 2022	3-7 October	Iceland	E-evaluation and interm report by November 2022	Lynda Blackadder
Year 2023	9-13 October	Tromso, Norway	E-evaluation and interm report by November 2023	New Co-chair-Isobel Bloor
Year 2024			Final report by November 2024	Co-chair expected

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 WG established a data call but will address known issues and improve and streamline the process. Data reporting, presentation and options for long term storage will be reviewed.	5.1	3 years	Include updated figures and tables in annual WG reports. Upload scripts to GitHub. Report on possible database options.
b	Review recent/current stock assessment methods of the main scallop species and explore other methodologies; including comparisons with fishery-dependent indicators and potential utilisation of oceanographic data within the assessment process.	The WG has made considerable progress to develop stock assessment methodologies for scallop species and this work should continue. Links have been established with WGNSSK to further consider SPiCT for scallop stock assessment, and with WGOOFE.	5.1,6.3	3 years	Report on stock assessments methodologies and results for all stock areas and consider reference points. Formalize the checking process for stocks. Establish working relationships with WGNSSK and WGOOFE.

c	Conduct a stock assessment for the northeast Irish Sea and work with WGOOFE to include environmental variables where appropriate.	Available data have been collated and work on this ToR in underway. Links established with WGOOFE, WGNSSK and WGSFD.	5.1, 6.2	3 years	Produce stock indices and apply SPiCT model (upload to Github). Analyse links with environmental variables. Develop ICES Viewpoint in cooperation with ACOM leadership and conduct Management Strategy Evaluation.
d	Review and report on current scallop surveys and share expertise, knowledge and technical advances. Review electronic monitoring (EM) for scallop fisheries.	Surveys continue to be important for data collection for scallop stocks and sharing knowledge of methodology and advances in technology is important as electronic monitoring and camera systems become more common.	1.5, 4.4, 5.4	3 years	Dredge efficiency review paper (link with ToR f). Scientific staff exchange on surveys. Report on EM and collaborate with WGSFD.
e	Continue to refine stock structure using best available information on genetics and larval dispersal and improve current mapping of scallop stocks. Establish links with WGOOFE to collaborate on specific work areas.	Undertsanding the biological stock area to determine if the assessment areas are apropriate. A number of new members have recently joined the WG and it is hoped the PhD projects can support this ToR.	1.4, 1.8	3 years	Report on PhD progress. Maps for each of the scallop stock areas.
f	Review current biological parameters 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. Differences in growth rates will be examined in detail. The group are reviewing dredge efficiency.	5.1, 5.2	3 years	Dredge efficiency review paper (link to ToR d). Report on growth studies.
g	Compare age reading methodologies and develop common practices and determine precision and bias of scallop age reading data derived from different readers.	Most institutes rely on aging methods and so this work is still important to continue.	4.4, 5.1	3 years	Attend WKSA. ICES TIMES document on aging methodologies.

h	Identify, list and collate all available data for queen scallops and agree on appropriate stock assessment areas. Share knowledge, draft a review paper and attempt stock assessments where possible.	The WG would like to focus more attention on this species. A subgroup will be formed to lead on this. Data are already collected through the data call and surveys.	5.1, 6.3	3 years	Report on progress. Draft a review paper. Create maps of stock areas.

Summary of the Work Plan

Year 1	LINKED TO TOR; A) REFINE DATA CALL, HIGHLIGHT AND ADDRESS ISSUES. B) CONTINUE TO EXPLORE INDEX STANDARDIZATION AND STOCK ASSESSMENT METHODOLOGIES INCLUDING SURPLUS PRODUCTION MODEL FOR SCALLOP STOCKS (AND ESTABLISH CLOSER LINKS WITH OTHER ASSESSMENT WGS (WGNSSK) C) APPLY A SPICT MODEL FOR THE ISLE OF MAN, USING SURVEY AND CPUE (VMS/LOGBOOK) INDICES STANDARDIZED WITH VAST. CONTINUE TO EXPLORE OTHER ALTERNATIVE MODELS AND ESTABLISH COMMUNICATIONS WITH WGOOFE. D) CONTINUE TO REPORT AND SHARE KNOWLEDGE OF SURVEYS AND PLAN FOR SCIENTIFIC STAFF EXCHANGE. F) DREDGE EFFICIENCY REVIEW PAPER H) FORM SUBGROUP FOR QUEEN SCALLOP WORK ESTABLISH LINKS WITH WGNSSK, WGSFD AND WGOOFE WITH REGULAR COMMUNICATIONS
Year 2	Linked to ToR; a) Data call - streamline and document checking process (upload scripts to GitHub) b) Review scallop ICES stock categories and discuss possible reference points (following ICES guidelines from WKREF2) c) Incorporate other spatial areas and environmental variables from the Irish Sea (collaborative work with WGOOFE) d) Undertake scientific staff exchange on scallop surveys. g) TIMES document on aging methodologies in collaboration with WKSA
Year 3	Linked to ToR; a) Data call – need to consider long term storage options (central database/RDB) b) Set up a more formal checking and review process for stock assessments c) Produce Viewpoint and Management Strategy Evaluation of Irish Sea scallops. d) Report on electronic monitoring (EM) for scallop fisheries and collaborate with WGSFD to produce mapping products. h) Queen scallop review paper

Supporting information

Priority	The current activities of this Group will lead ICES into issues related to the ecosystem effects of fisheries, especially with regard to the application of the Precautionary Approach. 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 resource required to undertake additional activities in the framework of this group is negligible.
Participants	The Group is normally attended by 25–30 members and guests.
Secretariat facilities	None.

Financial	No financial implications.
Linkages to ACOM and grou[p] under ACOM	There are no obvious direct linkages as this WG does not currently provide advice but we have discussed the possibility of developing a Viewpoint in cooperation with ACOM leadership for the work we are progressing for an Irish Sea stock assessment for king scallops.
Linkages to other committees or groups	There is a very close working relationship with WKSA, and we have provisionally agreed to work with members of WGOOFE, WGSFD and WGNSSK. Communication links have been established and the chair will seek to formalize agreements.
Linkages to other organizations	None

Annex 3: Further data call figures and 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	26.8	180.9	13.2	319.8	0	0.3	4.4	0	0	87.2	49.1	7.6
2006	43.7	330.4	54.9	446.9	0	0.3	24	3.2	0.5	22.4	6.9	0
2007	18.1	345.9	160.1	1167.4	4	1.9	89.4	6.1	2	95	11.2	7.4
2008	43.7	241.7	220.3	3961.9	0	25.4	215.4	0	0.2	111.8	3.3	8.6
2009	47.9	100.8	180.1	2309.5	0	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	48.6	479.3	59.3	3392.5	0	0.7	258.1	2.7	4.6	189.5	59.6	26
2013	141.9	475.5	49.2	1369.8	0	9.6	624.4	4.2	8	238.2	20.6	5
2014	67.6	605.6	118.2	1041.5	4.1	26.7	401.6	3.5	101.2	96.5	18.3	7.1
2015	9.1	238.5	63.3	387.6	11.1	22.6	119.9	9	75.9	76.5	58.1	28.2
2016	33.3	114.1	146.8	178.2	9.3	38.2	223	36.4	137.7	65	58.2	15.9
2017	59.1	92.3	21.3	184.3	3.8	10.9	105.6	0	105.8	82.4	15	0.1
2018	45.4	76.5	30.8	293.5	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
2020	0.7	109.8	75.1	838.4	0	2.7	156.6	14.9	5.6	46.6	57.6	4.9
2021	0	44.6	22.1	1366.2	0.3	1.4	162.7	5.3	3.8	56.4	13.4	0.5

Table 8 continued.

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

Year	36E4	36E5	36E6	36E7	37E3	37E4	37E5	37E6	37E7	38E4	38E5	38E6
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	48.5	0	9.7	165.4	715.2	10.3	0	119.1	231	36.9
2006	22.2	304.7	47.5	2	0	119.8	631.2	5.1	0	150.1	167.2	2.1
2007	33.4	424.7	187.2	0	0.2	248.4	878.3	12.2	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	278.2	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	76.8	1792	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	416.3	212.7	16.1
2016	109.8	2293.9	195.2	0	28.2	258.1	3571	7.6	0	402.2	319	2.9
2017	73.6	1378.7	154.3	0	3.9	293.2	2252.1	13.9	0	468.5	247.2	2.1
2018	77.8	1507.9	209.6	0	0	190.4	1901.5	6.5	0	357	192.1	3.8
2019	35.4	799.8	182	0	0.9	259.3	1525.8	5.9	0	229.8	205.7	0.5
2020	40.3	711.1	356.2	0	1	113.3	1168.3	5.7	0	237.3	152.2	15.4
2021	31.7	673.9	242.9	0	13.2	205.9	1424	2.6	0	227.9	86.7	0.7

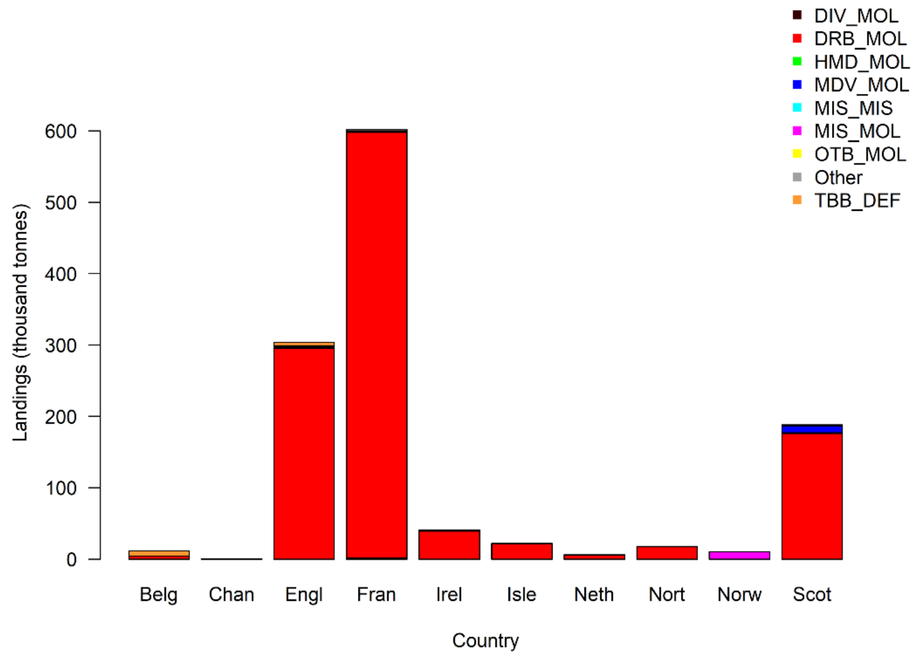


Figure 44 Landings of king scallops (live weight, thousand t) in the data call by country and métier. Métier classified to Level 5. The eight métiers with the highest landings are shown, with all others classified in to 'Other'. Begl is Belgium, Engl is England and Wales, Fran is France, Irel is the Republic of Ireland, Isle is the Isle of Man, Neth is the Netherlands, Nort is Northern Ireland, Norw is Norway and Scot is Scotland. DIV_MOL is divers targeting molluscs, DRB_MOL is dredges targeting molluscs, HMD_MOL is hand mechanised dredges targeting molluscs, MDV_MOL is also divers targeting molluscs, MIS_MIS is miscellaneous gear targeting miscellaneous species, MIS_MOL is miscellaneous gear targeting molluscs, OTB_MOL is bottom otter trawls targeting molluscs and TBB_DEF is beam trawls targeting demersal fish.

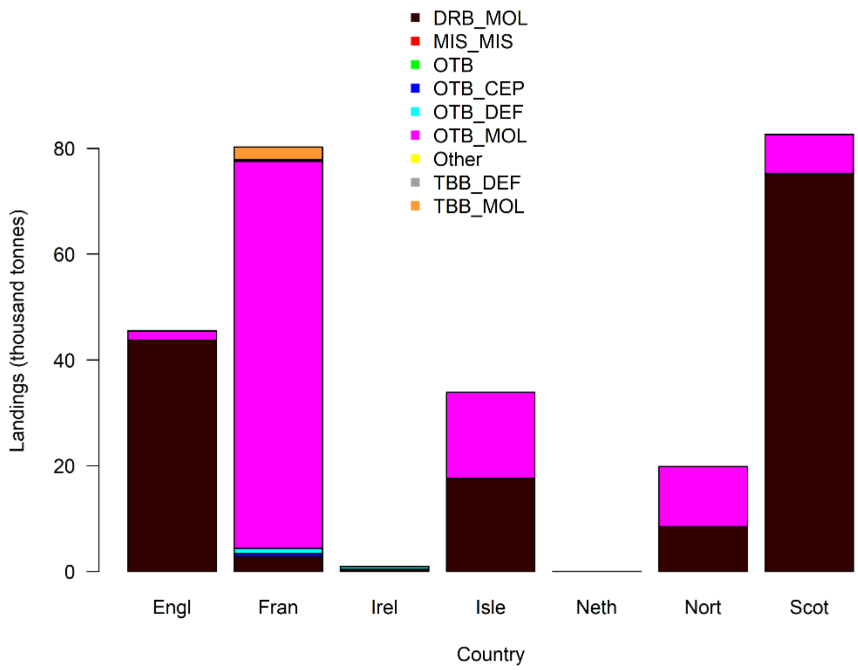


Figure 45 Total landings of queen scallops (live weight, thousand t) in the data call (2000-2021) by country and métier. Métier classified to Level 5. The eight métiers with the highest landings are shown, with all others classified in to 'Other'. Engl is England and Wales, Fran is France, Irel is the Republic of Ireland, Isle is the Isle of Man, Neth is the Netherlands, Nort is Northern Ireland, Norw is Norway and Scot is Scotland. DRB_MOL is dredges targeting molluscs, MIS_MIS is miscellaneous gear targeting miscellaneous species, OTB is bottom otter trawls (records not provided to Level 5), OTB_CEP is bottom otter trawls targeting cephalopods, OTB_DEF is bottom otter trawls targeting demersal fish, OTB_MOL is

bottom otter trawls targeting molluscs, TBB_DEF is beam trawls targeting demersal fish and TBB_MOL is beam trawls targeting molluscs.

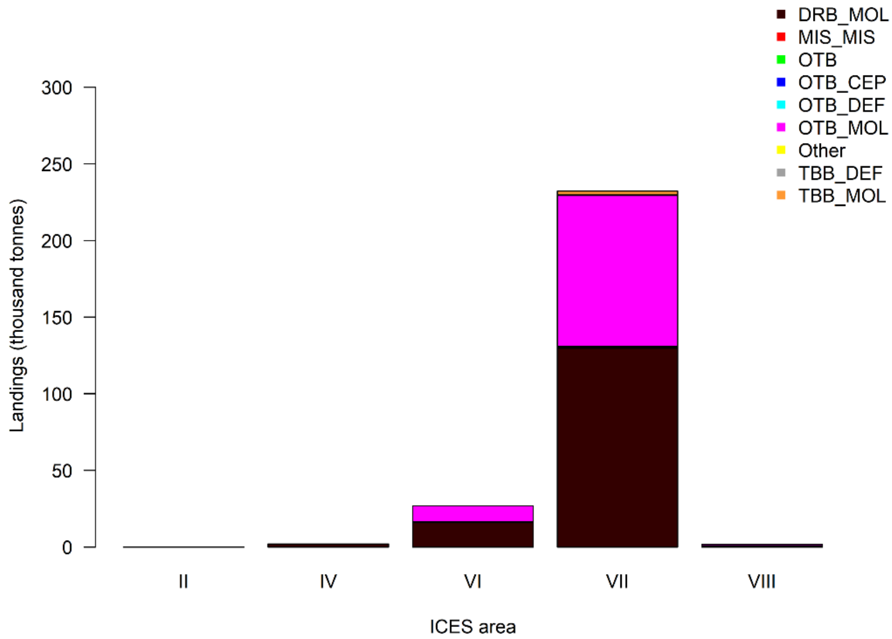


Figure 46 Total landings of queen scallops (live weight, thousand t) in the data call (2000–2021) by ICES area and métier. Métier classified to Level 5. The eight métiers with the highest landings are shown, with all others classified in to 'Other'. DRB_MOL is dredges targeting molluscs, MIS_MIS is miscellaneous gear targeting miscellaneous species, OTB is bottom otter trawls (records not provided to Level 5), OTB_CEP is bottom otter trawls targeting cephalopods, OTB_DEF is bottom otter trawls targeting demersal fish, OTB_MOL is bottom otter trawls targeting molluscs, TBB_DEF is beam trawls targeting demersal fish and TBB_MOL is beam trawls targeting molluscs.

Table 9 Provisional landings of king scallop 2000–2021 by Assessment Area and country, as provided to WGScallop.

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	258	260
	2007	2	0	0	0	0	0	285	287
	2008	0	0	0	0	0	0	370	371
	2009	0	0	0	0	0	0	394	394
	2010	0	0	0	0	0	0	361	361
	2011	0	0	0	0	0	0	699	700
	2012	0	0	0	0	0	0	991	991
	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	1054	1054

	2017	9	0	0	0	0	0	2505	2513
	2018	0	0	0	0	0	0	2322	2322
	2019	0	0	0	0	0	0	2333	2333
	2020	0	0	0	0	0	0	843	843
	2021	0	0	0	0	0	0	2502	2513
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	2411	9086
	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	15228
	2012	202	5711	0	0	0	0	3061	8975
	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	1897	6603
	2017	325	3952	228	0	0	0	3429	7933
	2018	277	7240	768	0	0	0	6160	14444
	2019	205	4260	581	1	0	0	6366	11413
	2020	247	2010	167	0	0	0	4655	7078
	2021	252	4625	910	0	0	0	7958	13745
27.7.e.I	2000	0	0	54	0	0	0	3674	3729
	2001	0	0	60	0	6	0	2523	2589
	2002	0	0	58	0	45	0	2045	2149
	2003	0	0	285	0	107	0	2380	2772
	2004	0	2	578	0	64	0	2901	3546
	2005	0	1	266	0	224	0	3331	3821
	2006	3	1	4	0	37	0	3286	3331
	2007	14	0	10	0	139	0	1557	1721
	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	1210
	2011	9	50	46	0	0	0	1869	1975
	2012	74	1	2	0	0	0	2554	2632
	2013	13	1	1	0	0	0	2508	2522
	2014	137	0	4	0	0	0	1710	1851
	2015	132	0	33	0	0	0	3823	3989
	2016	103	0	28	1	0	0	2878	3010
	2017	23	0	5	0	0	0	2413	2441
	2018	64	0	1	0	0	3	1810	1878

	2019	21	5	0	0	0	0	2065	2091
	2020	39	3	1	0	0	0	940	983
	2021	9	0	22	0	0	0	2021	2052
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	2889
	2006	2	3	0	0	2	0	2286	2293
	2007	8	30	0	0	1	0	2011	2051
	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	3010	3023
	2013	4	7	0	0	0	0	2407	2419
	2014	24	0	0	0	0	0	1896	1920
	2015	10	1	0	4	0	0	1367	1381
	2016	5	0	0	2	0	0	1562	1569
	2017	8	0	0	0	0	0	1713	1721
	2018	9	1	0	0	0	0	1905	1915
	2019	6	2	0	0	0	2	1691	1700
	2020	5	0	0	0	0	0	1474	1480
	2021	4	0	0	0	0	0	2031	2035
27.7.e.O	2000	0	1270	0	0	0	0	554	1824
	2001	0	944	0	0	32	0	578	1555
	2002	0	775	0	0	0	0	720	1496
	2003	0	880	1	0	0	0	1139	2020
	2004	0	965	0	0	0	0	700	1666
	2005	0	617	0	0	0	0	381	998
	2006	15	558	0	0	0	0	559	1131
	2007	42	1430	0	0	50	0	2407	3928
	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	3445
	2013	16	1008	2	0	0	85	2947	4060
	2014	104	1168	1	0	0	67	1285	2624
	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	900
	2018	15	193	0	0	0	215	1179	1603
	2019	9	163	0	0	0	417	1128	1716
	2020	7	245	92	0	0	239	1718	2300

	2021	18	787	231	0	0	158	3648	4842
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	19	22
	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	48
	2006	56	0	1	0	110	0	148	315
	2007	92	0	4	0	5	0	29	130
	2008	57	0	0	0	5	0	64	127
	2009	40	0	0	0	0	0	203	243
	2010	59	0	32	0	0	0	543	634
	2011	80	0	143	0	0	0	141	364
	2012	120	0	15	0	0	0	161	295
	2013	134	0	47	0	0	0	393	574
	2014	137	0	21	0	0	0	162	321
	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
	2020	57	0	75	0	0	0	185	317
	2021	54	0	7	0	0	0	24	85