SCALLOP ASSESSMENT WORKING GROUP (WGSCALLOP; outputs from 2023 meeting)

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Contents

i Executive summary

The ICES Scallop Assessment Working Group (WGScallop) collates and analyses scallop landings data, scallop surveys and methods, scallop ageing procedures and advances in technology in order to further develop and improve appropriate stock assessment methods.

Collated data from the 4th annual data call were reviewed and compared to data from the Regional Database Estimation System (RDBES). Further intersessional comparison work will be undertaken and if the two datasets match, then RDBES data can be used routinely and WGScallop will no longer issue an annual data call.

Fisheries independent surveys are critical for many stock assessment methods. The WG held an intersessional meeting on survey design and will continue further discussions during 2024. The first staff exchanges on scallop surveys occurred during 2023 and a list of surveys with available spaces for staff exchange have been compiled for 2024.

Scallop larval dispersal models have progressed in Scotland and Northern Ireland. Connectivity work among locations in the Irish Sea found that no significant spatial genetic differentiation among populations at the scale of ~ 400 km. There was however a significant genetic differentiation within samples that may be temporally linked to spring and autumn spawning. This hypothesis will be investigated using stable isotope analysis of king scallop shells from these two genetically distinct groups.

The Workshops on Scallop Aging have now concluded, and an update is provided.

WGScallop decided to combine two existing terms of reference,ToR B and ToR C, which are closely related and focus on developing stock assessment methods for scallops. A table was produced to highlight the international range of scallop stocks, current data and methods utilised, and a "road map" of best practice was suggested. An intersessional subgroup will meet to further discuss and consider options for a workshop.

New research on modifications to traditional dredge gear,i.e. skid dredges and n-viro dredges, to increase harvesting efficiency and decrease environmental impacts was presented. In addition, invited guests presented novel alternative harvesting methods involving pot fishing and suction methods.

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	2/3
Chairs	Lynda Blackadder, Scotland, UK
	Isobel Bloor, Isle of Man
Meeting venue(s) and dates	10–12 October 2023, Tromso, Norway, (29 participants)

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 missing data from countries with known scallop fisheries and inconsistencies in the landings when compared to national in-house data sources. The WG agreed an annual data call was required and drafted the request for landings and effort data for scallop species in ICES areas 2, 4, 5, 6, 7 and 8 and this has been issued annually by ICES since 2020.

WG members are asked to check the collated data and highlight any problems and at previous meetings these have been discussed. There was not time to discuss these fully at this year's meeting (as the number of days were reduced to three) and it has been proposed that work should continue intersessionally to allow further data checking. England submitted data on behalf of England and Wales and data for the Isle of Man were made available during the WG meeting.

Data tables and plots from the WGScallop data call are available in Annex 3. King scallops dominate the landings with the majority from ICES subarea VII (Table 1). 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 75 315 tonnes in 2022, which is the highest for the time-series. Please note there was a slight amendment to the 2021 reported landings (71 792 tonnes revised to 71 803 tonnes).

Table 1. 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

	ICES Subarea							
Year	I	II	IV	V	VI	VII	VIII	Total
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	61930	288.6	71803.3

	ICES Subarea							
Year	I	II	IV	V	VI	VII	VIII	Total
2022	0	0	4910.2	0	2207.1	67870.6	327.8	75315.7

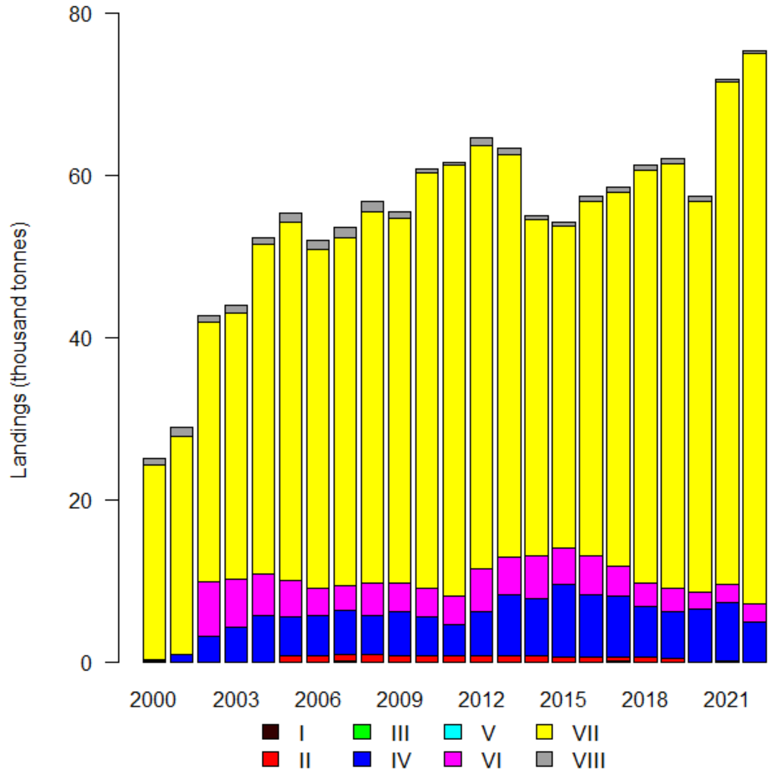


Figure 1. Annual landings (live weight (including shell), thousand tonnes) of king scallops from 2000–2021. Landings are divided by ICES subarea within each year, as coloured by the legend. Data for Isle of Man are not included prior to 2011 and Scotland are not included prior to 2002.

Last year, ICES provided a presentation on the Regional Database Estimation System (RDBES) and the group discussed the option of moving to using the "All species" RDB data call. The aim was to improve the quality of the fisheries data, address data storage and transparency concerns, and the new system would 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 WGScallop data call would continue, and that we would also complete intersessional work to compare data from the annual data call to the RDBES data extraction.

The WG requested the RDBES data extraction but because the data call closed just prior to the WGScallop annual meeting, the data were only made available a few days before the meeting. As a result, only preliminary work was undertaken during the meeting. It became apparent that whilst there appeared to be landings data for queen scallops, the other scallop species had been aggregated under one species code. No effort data were available for the WG but it was agreed that the focus should be on landings comparisons for now. Landings data for queen scallops showed considerable differences between the two data sources. Institutes were made aware of the differences and will contact their relevant data submitters to enquire the reason for these differences and will report back to the WG.

Intersessional work will continue to attempt to resolve the issues of the aggregated landings data for other scallop species and the results will be reported to the WG next year. The WG will continue to have a period of overlap, with the intention of fully moving to using data from the RDBES database at some point in future (if the data issues can be resolved). The WG will also enquire if the deadline for the RBDES data call could be earlier next year (to allow comparisons prior to the annual WG meeting).

It is hoped that moving to the RDBES may improve the data quality and the associated Governance group may facilitate discussions regarding scripts and protocols for data extractions and aggregations at the national institutes. The WG will ensure that the RDBES Governance group are aware of the issues identified at this meeting by providing feedback through ICES. **For next year, the group will discuss the possibility of a formal recommendation.**

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

To establish a systematic accounting of scallop stocks represented in the WG and their status in terms of stock assessment and advice, an overview table was created (Table 2). The resulting overview includes 25 stocks and reflects the wide range of scallop stocks in the WG in terms of species, geographical distribution, and assessment methods. It also highlights substantial data and capacity needs, as many scallop stocks are currently considered data-limited and often lack an analytical assessment. Currently, only several stocks in Scottish waters and the Irish Sea are assessed with analytical assessment models such as SAM. Most other stocks rely on biomass estimates from surveys or similar approaches.

The diversity of stock assessments and knowledge needs underlined the importance of aligning and sharing assessment approaches and capability within the WG. Although there are common underlying challenges - notably data limitations, uncertainties related to stock structure and life history/gear parameters, spatio-temporal variation, and patchiness - the discussion revealed often distinct stock- or country-specific obstacles to progress in stock assessments, typically related to input data. In addition, lack of capacity and resources was identified as another main hindrance to improved assessments and advice.

Considering the challenges of a coordinated approach to scallop assessment, the WG agreed on a two-pronged approach over the next years:

1. Creating a road map to guide scallop stock assessors to the most suitable assessment and advice methods given data and knowledge constraints.
2. Share and build assessment competence through subgroup workshops.

Table 2. Overview table of scallop stocks represented in WGScallop and their respective status in terms of stock assessment, advice and issues.

Species	Stock ID	Available input data	Assessment model(s)	Advice	Basis of advice	Reference points	Management measures	Environmental data	Issues/knowledge needs
Chlamys islandica	Iceland scallops in the Svalbard area	Survey estimates (2019-20, 2022), commercial CPUE (2022-2023)	Abundance/biomass estimation from geostatistical model	National/IMR (irregular)	Data-limited MSE (age-based, short cut)	Fmsy = 0.25, Fpgy = 0.19	TAC (15000t), MLS (60mm shell height), spatial restriction to 3 scallop beds in Bear Island area, impact assessment/reporting requirements	Temperature at survey stations, physical variables from ocean models (TOPAZ4/Copernicus, SVIM)	1. Very recent trial fishery, lack of time-series for stock assessment 2. Spatial stock structure uncertain, not accounted for in MSE 3. Limited knowledge of life-history parameters
Pecten maximus	Celtic Sea	Inconsistent survey time-series (2000-2005; 2019). From 2023 onwards, every 2-year survey Commercial CPUE (VMS/logbooks; dredge per boats)	Biomass estimation from geostatistical model	National	None	None	Scallop fishing license required. Total annual effort restrictions for the Scallop fleet. MLS (100mm shell width)	Backscatter data available. Physical variables from ocean models	1- Spatial variability in growth indicates need for a spatially explicit approach to assessment. 2- Age-based assessment limited by available data 3- Catchability is known to vary according to the ground type

Species	Stock ID	Available input data	Assessment model(s)	Advice	Basis of advice	Reference points	Management measures	Environmental data	Issues/knowledge needs
		Port-Sampling data							
Pecten maximus	Irish Sea	Inconsistent survey time-series. From 2023 onwards, every 2-year survey Commercial CPUE (VMS/logbooks; dredge per boats) Port-Sampling data	Biomass estimation from geostatistical model	National	None	None	Scallop fishing license required. Total annual effort restrictions for the Scallop fleet. MLS (100mm shell width); North of 52.2 degrees is 110mm shell width	Backscatter data available (sections). Physical variables from ocean models	1- Spatial variability in growth indicates need for a spatially explicit approach to assessment. 2- Age-based assessment limited by available data 3- Catchability is known to vary according to the ground type
Pecten maximus	French waters in Eastern Channel	Surveys time-series (1992-2023); catches and effort time-series	Direct biomass estimation from survey indexes; CMSY++	National			Scallop fishing license required. Length, power and number of dredges limits. Effort restrictions (fishing allowed from October to mid-May, 3 or 4 days per week, 2 to 6hours/day, rotational closure in the Bay of Seine). High selectivity of gear (97mm inside diameter for dredge rings). MLS=110mm. Limitation of catches/trip.		
Pecten maximus	French waters in Western Channel	Surveys time-series (1974-2023, standardized since 1992); catches and effort time-series	Direct biomass estimation from survey indexes	National			Scallop fishing license required. Length, power and number of dredges limits. Effort restrictions (fishing allowed from October to mid-May, 1 or 2 days per week, 1 hour/day in the Bay of Saint-Brieuc). High selectivity of gear (97mm inside diameter for dredge rings). MLS=102mm. Annual TAC in the bay of Saint-Brieuc.		
Pecten maximus	NI waters in Via and VIIa	Survey time-series (1992-2023); observer programme; commercial CPUE based on kwdays (no dredge information available)	Trend based	National	ICES category 3	None	Scallop fishing license required. Total annual effort restrictions for the Scallop fleet. MLS 110mm. Irish sea closure. Weekend closure. Fishing only allowed between the hours of 0600-2000. Gear restrictions, 6-per-side. Spatial closues.	Backscatter and habitat maps; oceanology data available.	
Pecten maximus	Irish Sea: IoM 12 nm miles	Research survey time-series (1992-2023); Industry survey time-series (2019 - 2023). VMS data for whole fleet regardless of vessel size - since 2015 15 min pings. Daily Catch Returns for all vessels for TS landings with	Trend based	National	ICES category 3	None	IoM scallop fishing license required. Limit on licences. Annual TAC. Daily Catch Limits, MLS 110mm. Irish sea closure. Fishing only allowed between the hours of 0600-1800. Gear restrictions, 5-per-side (0-3 nm), 6-per-side (3-12 nm). Permanent and temporary spatial closures.	Habitat map for territorial sea (2008)	Grounds are very distinct in Isle of Man with variable recruitment, growth rates and densities both spatially and temporally which need to be incorporated into a model. We manage more and more on a fishing ground level so an overall stock assessment would need to be complemented with a finer-scale assessment for management. We also have the complication of being part of a wider Irish Sea stock.

Species	Stock ID	Available input data	Assessment model(s)	Advice	Basis of advice	Reference points	Management measures	Environmental data	Issues/knowledge needs
		gear information and fishing time etc.							
Aequipecten opercularis	Irish Sea: IoM 12 nm miles	Research survey time-series (1992-2023); Industry survey time-series (2019 - 2023). VMS data for whole fleet regardless of vessel size - since 2015 15 min pings. Daily Catch Returns for all vessels for TS landings with gear information and fishing time etc.	CSA (length based)	National	ICES category 3	Use of LPUE thresholds and swept area	IoM scallop fishing license required. Limit on licences. Annual TAC. Weekly Catch Limits, MLS 110mm. Irish sea closure. Weekend closure. Fishing only allowed between the hours of 0600-1800. Permanent and temporary spatial closures.	Habitat map for territorial sea (2008)	Grounds are very distinct in Isle of Man with variable recruitment, growth rates and densities both spatially and temporally which need to be incorporated into a model. We manage more and more on a fishing ground level so an overall stock assessment would need to be complemented with a finer-scale assessment for management. We also have the complication of being part of a wider Irish Sea stock.
Pecten maximus	Shetland	Inconsistent survey time-series from 2007 (9 years of data); observer programme (Factories and vessel); commercial LPUE (logsheets since 2000)	VPA(length based), Trend based, direct biomass estimations from survey indices	Regional out to 6nm		LPUE thresholds	SSMO fishing licence required. Night-time curfew (0600- 2100) and dredge limits. MLS 100mm. Spatial closures for ETP species. Moratorium on additional effort since 2019.		Looking at developing SSB reference point. Resolving VPA approach or develop new reference points based on survey data.
Aequipecten opercularis	Shetland	Commercial LPUE (logsheets since 2000)	Trend based	Regional out to 6nm		None	SSMO fishing licence required. Night-time curfew (0600- 2100) and gear specifications. MLS 50mm. Spatial closures for ETP species.		Mostly a bycatch fishery but varies year-to-year.
Pecten maximus	Shetland	Catch-at-age data (Ages 3-10+, Final year 2022 (start year dependent on area)) Survey indices (Ages 3-9 (age 10+ often very noisy so exclude), Final year 2022) Indices are vessel specific due to differing catchability (observed in previous assessments), Trialling weighting of input	SAM (previously TSA)	National		None	Licensed fishery. MLS 105 mm. Gear restrictions (no. dredges and bar length capped) depending on area fished. Requirement for REM. Some areas subject to seasonal closures.		Sampling levels are low for most assessment areas. Requirement for more regular assessment updates. Survey stations at risk due to spatial squeeze (closed areas for MPAs and renewables).
Pecten maximus	North East		SAM (previously TSA)	National		None			
Pecten maximus	East Coast		SAM (previously TSA)	National		None			
Pecten maximus	Orkney		NA	NA		NA			

Species	Stock ID	Available input data	Assessment model(s)	Advice	Basis of advice	Reference points	Management measures	Environmental data	Issues/knowledge needs
Pecten maximus	North West	data- use of number of survey tows/commercial samples Weight at age and maturity at age (all assumed mature)to calculate spawning biomass	SAM (previously TSA)	National		None			
Pecten maximus	West of Kintyre		SAM (previously TSA)	National		None			
Pecten maximus	Clyde					None			
Aequipecten opercularis	Scotland	Landings. Survey data (king scallop survey). Sporadic market sampling.		NA. No advice issued.					Relatively small fishery for Scotland.
Pecten maximus	Division 27.4.b, inshore along York-shire/Durham coast	Scientific dredge survey conducted annually by Cefas; swept-area estimates with supstrate-specific gear efficiency parameters	Spatial interpolation between survey sites within fixed assessment areas	None yet; UK Fisheries Management Plan in development	Spawner-per-recruit population model, based on sampling data from annual dredge surveys	MSY-proxy, harvest rate consistent with 35%VSpR	UK scallop fishing license; MLS of 100 mm shell length	None	Uncertainties about gear efficiency parameters for different substrate types and weather conditions
Pecten maximus	Division 27.7.d, north of 50ºN	Scientific dredge survey conducted annually by Cefas; swept-area estimates with supstrate-specific gear efficiency parameters	Spatial interpolation between survey sites within fixed assessment areas	None yet; UK Fisheries Management Plan in development	Spawner-per-recruit population model, based on sampling data from annual dredge surveys	MSY-proxy, harvest rate consistent with 35%VSpR	UK scallop fishing license with restrictions under UK Western Waters Effort Regime; MLS of 110 mm shell length; UK EEZ closed season July - September (in 2023, under review), under-10-m vessels exempt; French EEZ closed season 15 May - 30 September for all vessels fishing for scallops	None	Uncertainties about gear efficiency parameters for different substrate types and weather conditions
Pecten maximus	Division 27.7.e	Scientific dredge survey conducted annually by Cefas; swept-area estimates with supstrate-specific gear efficiency parameters	Spatial interpolation between survey sites within fixed assessment areas	None yet; UK Fisheries Management Plan in development	Spawner-per-recruit population model, based on sampling data from annual dredge surveys	MSY-proxy, harvest rate consistent with 35%VSpR	UK scallop fishing license with restrictions under UK Western Waters Effort Regime; MLS of 100 mm shell length; Lyme Bay closed season July - September (in 2023, under review), under-12-m vessels exempt	None	Uncertainties about gear efficiency parameters for different substrate types and weather conditions
Pecten maximus	Division 27.7.f, inshore along northern Cornwall coast	Scientific dredge survey conducted annually by Cefas; swept-area estimates with substrate-specific gear efficiency parameters	Spatial interpolation between survey sites within fixed assessment areas	None yet; UK Fisheries Management Plan in development	Spawner-per-recruit population model, based on sampling data from annual dredge surveys	MSY-proxy, harvest rate consistent with 35%VSpR	UK scallop fishing license; MLS of 100 mm shell length	None	Uncertainties about gear efficiency parameters for different substrate types and weather conditions
Pecten maximus	Welsh waters	2012-2023 annual scientific dredge survey, swept-area densities with no gear efficiency correction. Size, age, maturity data collected.	Looking at methods that don't need catch data due to difficulties/uncertainty with VMS/Landings	Will need to advise when FMP comes into effect			110 mm MLS inside 12 nm, 100 mm outside. Closed season inside 12 nm. Dredge limits inside 12 nm.		Poor catch data - difficulties with VMS data to allow linking of landings to VMS. This needs to be done due to the ICES rectangles crossing different management regimes (MLS, gear and season).

Species	Stock ID	Available input data	Assessment model(s)	Advice	Basis of advice	Reference points	Management measures	Environmental data	Issues/knowledge needs
Pecten novaezelandiae	New Zealand	Scientific dive and dredge survey data (various areas surveyed 1990-2021), and camera survey data in 2022; length-greenweight and meatweight recovery from greenweight data; dredge efficiency/selectivity parameters for NZ ring-bag and box dredges, derived from modelling of paired gear (dive-dredge) sampling data.	Biomass estimation from swept-area survey data corrected for dredge efficiency. An assessment model has not been developed.	National	Series of recruited (harvestable) biomass estimates for the areas surveyed, at a range of threshold density levels. Series of prerecruit abundance estimates.	Targets: Fishing mortality at or below Fmsy as approximated by F0.1; Empirical target harvest (exploitation rate) Umsy = 0.07 for Marlborough Sounds (substock within SCA7). Limits: soft limit = 20% B0; hard limit = 10%B0.	The main NZ scallop fisheries (SCA1, SCACS, SCA7) are currently fully closed due to sustainability concerns about overall low abundance. Scallops are managed under the NZ Quota Management System. Multiple management measures include: catch limits (TAC for each QMA, comprises a TACC and allowances for customary, recreational, and other sources of mortality); MLS of 90 mm or 100mm depending on area and fisher type (customary/recreational or commercial); spatial and temporal restrictions (no-dredging areas, fishing seasons); effort controls (gear type/size, fishing hours/days).	Various environmental data are available but have not been used in assessments to date.	Priority work in 2023-24 is: 1) to review and develop appropriate reference points for NZ scallops; 2) to investigate and evaluate the utility of fine-scale CPUE data; 3) to develop camera and AI-based survey methods. Reanalysis of historical survey data is also needed to better address temporal changes in the spatial extent and stratification of the areas surveyed, to produce more robust time-series. Other issues include habitat degradation from the effects of fishing (dredging) and non-fishing factors (e.g. land-based sedimentation), which reduce habitat suitability.
Pecten maximus	Jersey, Channel Islands	Dredge Survey data, initial dive survey data, Age data (1 yr), daily fishery landings and VMS data		for Jersey Waters, produced 2024			MLS 102, Dredge ring size and construction regs, no shucking at sea	Various camera surveys	Need to determine if MLS move can improve fishery through additional spawining cycle. Need to develop an intelligent method for managing fishery by area with realistic harvest control limits
Aequipecten opercularis	NI waters in Via and VIIa	Survey time-series 2013-2023; Commercial CPUE	Trend based	National	ICES category 4	None	Fishing license required. MLS.	Backscatter and habitat maps; oceanology data available.	

Trials of use of DLS models in France (based on Surplus production models)

In the English Channel, three different stocks of King scallop have been considered. Two stocks are located in the Western Channel, one in the South for the Granville Bay including the bay of Saint-Brieuc (7 ICES rectangles 26E6 to 26E8, 27E6 to 27E8 and the part of 28E8 in division 7e), the second in the North near England coast (8 ICES rectangles 28E4 to 28E6, 29E5 to 29E7, 30E6 and 30E7). One single-stock is considered in the Eastern Channel (all rectangles in division 7d). A focus on the Bay of Seine (two rectangles 27E9 and 28E9) has also been completed. International catch data (France, UK and Ireland) are coming from ICES database (2000–2021). For the two "French" stocks, abundance indices time-series from the French assessment surveys are used (respectively COSB in the West and COMOR in the East).

In order to assess the state of these stocks, we used a model developed for the study of data-limited stocks, the CMSY model (Martell and Froese, 2013), optimized in a more recent version CMSY++ (Froese *et al.*, 2020; Froese *et al.*, 2021). Results of the Cmsy++ assessment are synthetized in the Kobe plots in Figure 2 and Figure 3. The stock in the Bay of Seine, in French territorial waters, was severely depleted in the early 2000's, with chronic overfishing. The situation has improved significantly over the last ten years. For the last five years, the stock could be considered in good condition. The situation is a little bit different at the Eastern Channel level, where globally the exploitation rate is less than in the Bay of Seine. The status of the stock could be considered in a good situation, but the recent trend with increase of fishing mortality may be a concern.

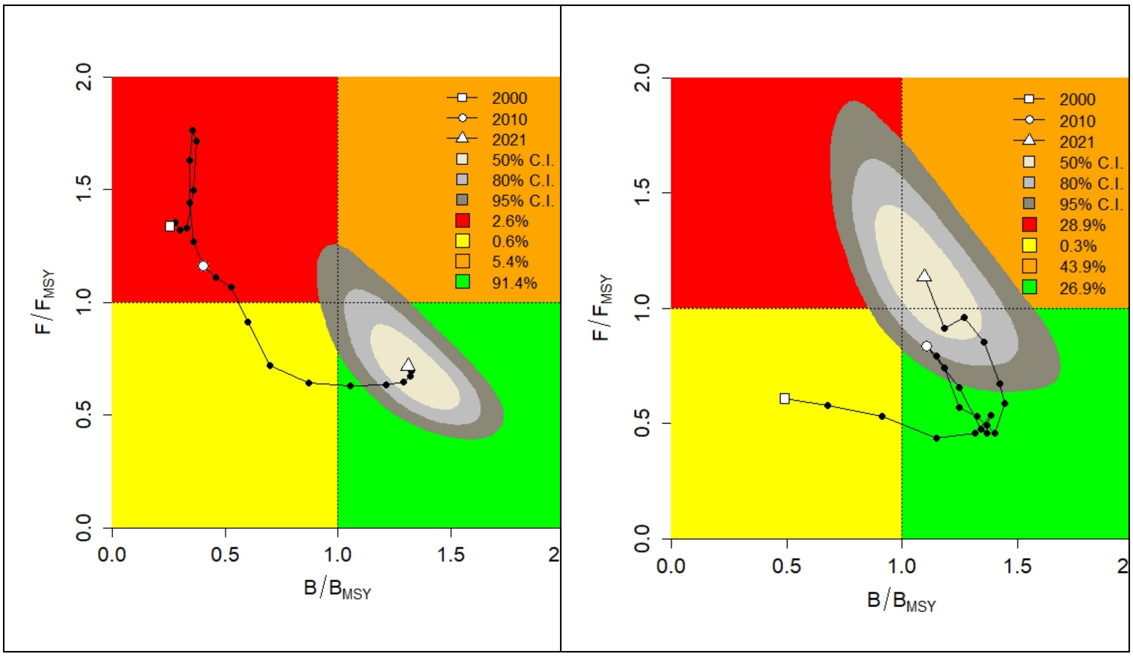


Figure 2. Kobe plots (stock status) for the Bay of Seine (left) and the Eastern Channel (right).

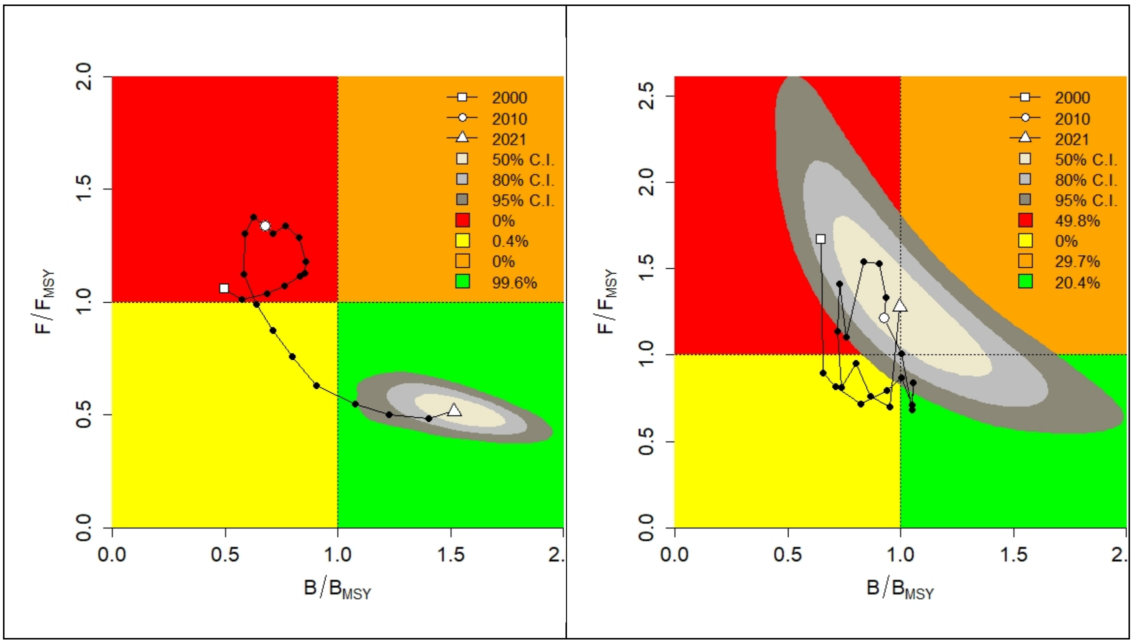


Figure 3. Kobe plots (stock status) for the Granville Bay of Seine, including the Bay of Saint-Brieuc (left) and the Northern waters of Western Channel (right).

The status of the stocks is clearly different in the two parts of Western Channel. The Bay of Saint-Brieuc, as the Bay of Seine in Eastern Channel, was severely depleted at the beginning of the time-series, and progressively improved. Today the exploitable biomass is significantly above the B_{msy}, and the exploitation ratio (F/F_{msy}) is less than 1. In the northern Western Channel, the assessment shows that B/B_{msy} is close to 1 and that F/F_{msy} is over 1 and that fishing mortality is likely to be too high. Nevertheless, there is no evidence of significant stock depletion or very obvious overfishing and the stock status overall seems to be improving.

Update on Scottish scallop stock assessment (*Pecten maximus*)

Stock assessments for king scallops (*Pecten maximus*) in Scottish waters were last published in 2017, utilising survey data up to 2016 and commercial catch-at-age data to 2015. The report detailed analytical assessments using Time Series Analysis for five assessments areas; East Coast, North East, Shetland, North West and West of Kintyre.

Updates to these assessments have been delayed due to limited staff resources and a number of prioritisation and restructuring exercises within the Scottish Marine Directorate. In addition, there has been a requirement to adopt a new approach for estimating the scallop catch-at-age data which was previously carried out within an inhouse database (Fisheries Management Database). The database is no longer supported and the process is now undertaken through a series of R scripts which attempt to replicate the previous database internal calculations. Catch estimation has been carried out using this new approach for 2009 onwards to allow for comparison with historical data. Estimates from the old and new approach are largely in agreement.

Age-structured survey indices are also used in the stock assessments. These are derived from the Scottish dredge surveys (see ToR g) and calculated as a weighted average (by tow duration) of the catch rate in numbers per hour per dredge width.

The new assessments are being implemented in a state-space assessment model (SAM). The state of the stock in a particular year is described by a vector of stock numbers-at-age and fishing mortality numbers-at-age (the 'state vector'). The 'state equations' define how this vector changes over time i.e. how the numbers-at-age in a particular year relate to the numbers-at-age and fishing mortality-at-age in the previous year. This vector is related to the data or observations (typically catch-at-age data and survey data) through 'observation equations'. Preliminary assessment results (for two of the assessment areas; Shetland and East Coast) were shared with WG members.

SAM is a widely used stock assessment method within ICES with an online platform on which assessments can be run and made publicly available (www.stockassessment.org). Preliminary assessments are ongoing but should be completed by the end of 2023, with an assessment report available in 2024.

Review of reference points (management targets and limits) for New Zealand scallops (*Pecten novaezelandiae*)

Scallops (*Pecten novaezelandiae*) are highly valued by customary, commercial and recreational fishers in Aotearoa-New Zealand (New Zealand), but major declines in scallop abundance have led to closure of the country's main scallop fisheries (SCA 1 Northland, SCA CS Coromandel, and SCA 7 Southern) (Fisheries New Zealand 2022). Scallop productivity, a function of the biology of the species and the environment in which it lives, appears to have changed in some areas, likely due to a combination of environmental changes and the effects of fishing (NIWA 2012). Evaluation of assessment and management approaches is underway, together with consideration and development of alternative approaches.

A key requirement is the setting of appropriate target and limit reference points for each scallop stock, against which the status of the stock can be assessed and managed. Detailed guidance on setting reference points is provided in New Zealand's Harvest Strategy Standard (Ministry of Fisheries 2008, 2011), a policy statement of best practice in relation to the setting of fishery and stock targets and limits for fishstocks in the Quota Management System (QMS). For this brief overview, the following definitions and depiction of reference points (i.e. performance measures) have been sourced from Fisheries New Zealand (Figure 4):

"Stocks are assessed against 4 performance measures:

A hard limit – a biomass level below which a stock is deemed to be collapsed and fishery closures should be considered to rebuild the stock at the fastest possible rate.

A soft limit – a biomass level below which a stock is deemed to be overfished or depleted and needs to be actively rebuilt using a formal, time constrained rebuilding plan.

A management target – the level of biomass or a fishing mortality rate that stocks are expected to fluctuate around for the best balance between use and sustainability, while allowing for environmental variation.

Overfishing threshold – a rate of extraction (percentage of a stock removed each year) that should not be exceeded as it will ultimately lead to stock biomass falling below other performance measures."

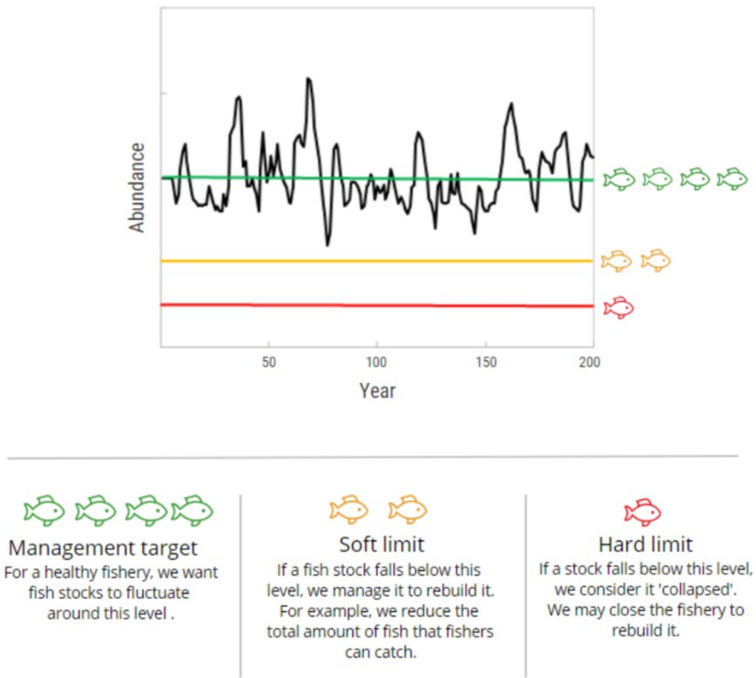


Figure 4. Diagram illustrating the relationship between the four performance measures. The trace of stock abundance is the result of fishing just below the overfishing threshold. Stock abundance fluctuates around the management target and sometimes approaches the soft limit but never goes below this level and stays far above the hard limit. Management action to ensure the stock continues to fluctuate around the management target would normally be taken at all points where the stock dips too far below the target. Figure and text directly sourced from Fisheries New Zealand .

It is recognised that fishing mortality rate (*F*) based reference points may be more appropriate as target reference points for scallops than biomass-based reference points given the high fluctuating nature of recruited scallop biomass over time (Smith *et al.*, 2016). Research also shows that scallops are vulnerable to recruitment overfishing (Orensanz *et al*,. 2016), and limit reference points may be set to protect minimum spawning-stock biomass levels to avoid the risk of recruitment overfishing.

Previous management of New Zealand scallop fisheries has used an *F*-based target approach, calculating Current Annual Yield (CAY) using an $F_{0.1}$ target derived from yield-per-recruit (YPR) modelling and recruited biomass estimated from a survey (Fisheries New Zealand 2022).

Estimates of $F_{0.1}$ have been high and this has resulted in overestimation of yield, particularly when fishing tends to focus on a small proportion of the biomass. Recognising this, a revised approach for the Marlborough Sounds substock (within SCA 7) was implemented in 2015 which calculated an empirical target harvest (exploitation) rate based on a period when the biomass was stable of increasing (i.e. the aim is to avoid harvest rates that tend to lead to biomass decline).

A new research project commenced in September 2023 to review the existing reference points (targets and limits) for scallops in the SCA 7 Marlborough Sounds substock and develop reference points for the other main scallop stocks: Northland SCA 1, Coromandel SCA CS, and SCA 7 Golden Bay / Tasman Bay. To achieve this objective, the project approach involves three main tasks:

1. Reviewing international best practice in the setting of reference points for scallop fisheries assessment and management.
2. Establishing a framework for setting reference points for New Zealand scallops that appropriately takes account of the fishery effects (e.g. benthic habitat damage from dredging) and non-fishery effects (e.g. land-based sedimentation) which influence scallop productivity.
3. Reviewing and developing appropriate reference points for the four key scallop stocks (SCA 7 Marlborough Sounds, SCA 7 Golden/Tasman bays, SCA 1 Northland, and SCA CS Coromandel). For each stock, the available knowledge and data required will be reviewed and assessed, and knowledge/data gaps will be identified.

3 TOR C: Conduct a stock assessment for the north-east Irish Sea and work with WGOOFE to include environmental variables where appropriate

For Year 2 of this ToR, work has focused on creating an index of Landings per Unit Effort (LPUE) using logbook and Vessel Monitoring Systems (VMS) data. Initial exploratory analyses used Irish and Isle of Man data and included detailed analysis of the merging process and potential spatial and temporal issues in the process for scallop fisheries specifically. The group have also investigated refining the classification of fishing points using a clustering algorithm based on distance in addition to classification by speed ranges.

In the Isle of Man, the LPUE index calculated from merged logbook and VMS data were compared to the LPUE index calculated from daily catch return data (which are submitted by fishers at the end of each day of fishing activity for scallops within Isle of Man territorial waters), and includes information on fished time (mins), location (fished ground) and landings (tonnes). Comparison of these two indices (Figure 5) revealed differences in scale and trend in the first two seasons of the datasets (2017/18 and 2018/19) but were more closely related in the later three seasons (2019/2020, 2020/2021 and 2021/2022).

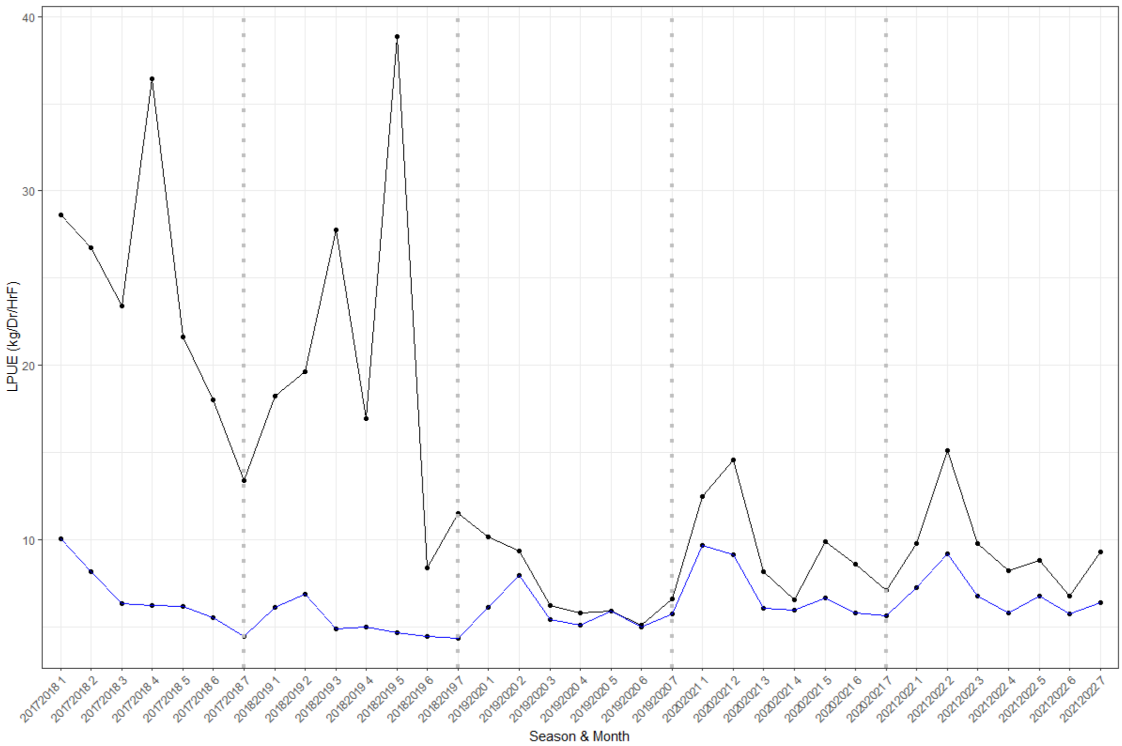


Figure 5. Comparison of LPUE (kg per dredge per hour fished) indices from Nestforms daily catch returns (blue line) and merged logbook and VMS data (black line) for king scallops fished in Isle of Man waters from 2017/18 to 2021/22.

Further exploration of the data indicates that whilst the required ping rate for scallop fisheries within Isle of Man changed from every 120 minutes to every 15 minutes in November 2016 there remained a mix in ping rates until the start of the 2019/20 fishing season when the majority of fishing trips were recording 15-minute pings. The data indicates that where 120-minute ping rates are more common there is a tendency for LPUE to be over inflated in trips which have fewer valid pings at fishing speed, as total fishing time tends to be underestimated. An analysis for those years with 15-minute ping rates is currently underway to assess the variance in LPUE indices when comparing data calculated from 15-minute ping rate intervals against the same data subsampled at 120-minute ping intervals. Variance in these two related datasets will be assessed both spatially and temporally so that an assessment on the validity of using these indices for scallop assessment across the Irish Sea area (which is an area that crosses multiple jurisdictions and regulations for VMS data collection and ping rates) can be made.

Environmental data were supplied by the Working Group on Operational Oceanographic products for Fisheries and Environment (WGOOFE) and progress made incorporating these into analysis for the Irish Stock, although the resolution of the data makes it hard to assess meaningful relationships.

As part of the working group discussions at the meeting it was decided to combine ToR B and ToR C which are closely related and focus on developing stock assessment methods for scallops. The WG plans to use the data collated across the Irish Sea area, from multiple jurisdictions, as a case study for the methods proposed as part of ToR B.

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

Surveys of the main scallop fishing grounds continue to be a critical input data source for many stock assessment methods and are undertaken annually by many institutes. Discussion this year highlighted that many surveys are under threat because of cuts to funding. WG members agreed that, for many institutes, annual scallop surveys provide important time series data and any changes to the vessels, survey design or methodologies can pose problems for assessments.

A subgroup met in January 2023 to discuss survey design methods for scallops. It was agreed that this meeting was useful and a second meeting will be scheduled for 2024. The meeting provided knowledge and insight for researchers who are relatively new to survey methodologies and may lack the technical experience, and also provided a forum for discussing possible areas of continuous improvements - especially for those institutes who have established time-series but are willing to learn and share new or developing methods.

A successful staff survey exchange occurred in April 2023 with Isle of Man hosting a staff member from Jersey Government on their scallop survey. A table with available spaces for staff on members surveys has been compiled again for 2024. WG members agreed this is a valuable exercise and want staff exchanges to continue but noted that some institutes still have significant travel and budget restrictions in place.

Table 3. A summary of scallop surveys and any issues or disruptions 2021–2023

Country	Target species	Typical/planned surveys	2021	2022 Update	2023 Update	Other issues (weather/funding/ship/staff)
England	King scallop	Annual dredge survey Western English Channel and Celtic Sea (selected areas)	No Covid disruption	Completed May 2022	Survey in Division 27.7.e completed May 2023; survey in 27.7.f abandoned due to poor weather conditions	Logistics prevented survey in assessment area 27.7.f.I
England	King scallop	Annual drege survey Eastern English Channel and North Sea (selected areas)	No Covid disruption	Completed September 2022	Surveys in Division 27.4.b and 27.7.d completd September 2023	Recently defined survey area 27.4.b.D not carried out
England	King scallop	UWTV survey in selected unexploited areas	Relocated from English Channel to North Sea	Scheduled November 2022	Carried out in June 2023 but affected by technical issues; only half of one survey area could be completed	
France	King scallop	Annual survey, Bay of Saint-Brieuc (VIIe,26e7)	No Covid disruption	Completed September 2022	Completed 2023	Old vessel (44 years old) which will be

Country	Target species	Typical/planned surveys	2021	2022 Update	2023 Update	Other issues (weather/funding/ship/staff)
						replaced from 2024 onwards
France	King scallop	Annual survey, Bay of Seine (7d,27E9 and 28E9)			Completed 2023	Threat to future funding of scallop survey
Iceland	Iceland scallops	Annual drop camera survey	Cancelled	Scheduled in 2023	Cancelled	Cancelled due to lack of funding
Ireland	King Scallop	Dredge Survey	No covid disruption	Scheduled December 2022	Rescheduled for 2024	Survey to be carried in 2024
Ireland	King Scallop	Dredge survey - Celtic Sea and Tuskar	No Survey	Scheduled in 2023	Rescheduled for 2024	Last done on 2019. Survey to be carried in 2024
Ireland	King Scallop	Dredge Survey - North Irish Sea		Scheduled in 2023	Rescheduled for 2024	New survey
Isle of Man	King and queen scallop	Annual scientific survey	Went ahead adhering to CV regulations (i.e. reduced scientific staffing)	Completed April 2022	Completed April 2023	
Isle of Man	King and queen scallop	Annual Industry survey	Went ahead adhering to CV regulations	Completed April 2022	Completed April 2023	Industry research funding scheme set up to fund surveys
Jersey	King scallop	Annual dredge survey, started 2021	Initial baseline survey completed, refining method for 2022	2022 survye completed September. 44 sites.	2023 survey completed September. 32 sites.	
Northern Ireland	King scallop	Annual dredge survey	No disruption	Completed Feb 2022	Completed Feb 2023	
Northern Ireland	Queen scallop	Annual UWTV and fishing survey (June/July)	No disruption - survey back to normal	Completed July 2022	Completed July 2023	
Norway	Iceland scallops	Irregular scientific survey	No survey	Completed September 2022	No survey 2023 (No funding)	No survey planned for 2024 (No funding)
Norway	King scallop	Irregular scientific diving survey	Cancelled	Completed May/June 2022	Completed June 2023	

Country	Target species	Typical/planned surveys	2021	2022 Update	2023 Update	Other issues (weather/funding/ship/staff)
Scotland	King scallop	Annual dredge survey - Shetland (15 days)	Reduced scientific staff and crew reduced sampling capability, vessel in port every night	Completed - Jan/Feb 2022	Completed Jan/Feb 2023	
Scotland	King scallop	Annual dredge survey - West coast of Scotland (21 days)	Reduced scientific staff and crew reduced sampling capability, vessel in port every night	Completed - May 2022	Completed Mar/April 2023	
Scotland	King scallop	Annual dredge survey - East coast of Scotland (20 days)	Reduced scientific staff and reduced sampling capability	Completed - July 2022	Completed July 2023	
Scotland	King scallop	Dredge survey - Clyde (14 days)	Disrupted due to Covid, Half survey complete	Due November	Completed October 2023	
USA	Sea scallop	Annual drop camera survey	Survey completed	Survey completed	Survey completed	
Wales	King and queen scallop	Annual survey	Reduced scientific crews prevented camera sampling at night, and loss of bycatch processing at some stations.	Completed April 2022	Started May 2023 - mechanical with boat so completed August 2023	

Norway update. King scallop (*Pecten maximus*)

A commercial king scallop diver-fishery was developed in Norway during the early 1990s with the main fishing area at Frøya in Trøndelag County (ICES assessment area IIa). In 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 6), and while the landings in Trøndelag have decreased from a maximum of 892 tonnes in 2008 to 136 tonnes in 2021, landings in Nordland County have varied between 106 and 235 tonnes per year since 2014. In 2022 the total landings were 383 tonnes (value 1.14 million Euro), where 207 tonnes were landed in Trøndelag and 176 tonnes landed in Nordland. 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.

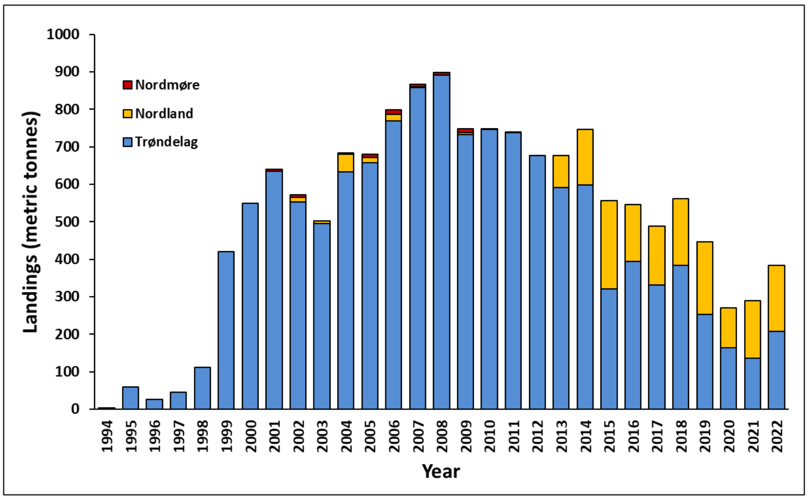


Figure 6. Landings of king scallop (Pecten maximus) in Norway by commercial scallop divers in the period 1994–2022. Data from the Norwegian Fishermen's Sales Organization.

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

As a part of the "National marine habitat mapping program" areas of high abundance of the great scallop *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 combining topographic information from sea maps with anecdotal knowledge of scallop distribution pattern. During 2009–2019 data from a total of about 850 tows from Rogaland (South-Western Norway) to Nordland (North Norway) Counties were collected. It is possible to do coarse estimation of scallop size based on the video recordings, but it is not possible to do age reading. Also, 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 monitoring by collecting live scallops for obtaining measures of size and age.

Since the mid-1990s the Institute of Marine Research (IMR) has irregularly monitored the commercially exploited stocks in Trøndelag County to assess age distribution (1993, 1997, 2006, 2007, 2010 and 2022). This monitoring is conducted by scientific divers collecting live scallops for measuring growth and determine age and yearly growth. 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 1 to 8 are represented, although the domination of certain age groups varies (Figure 7).

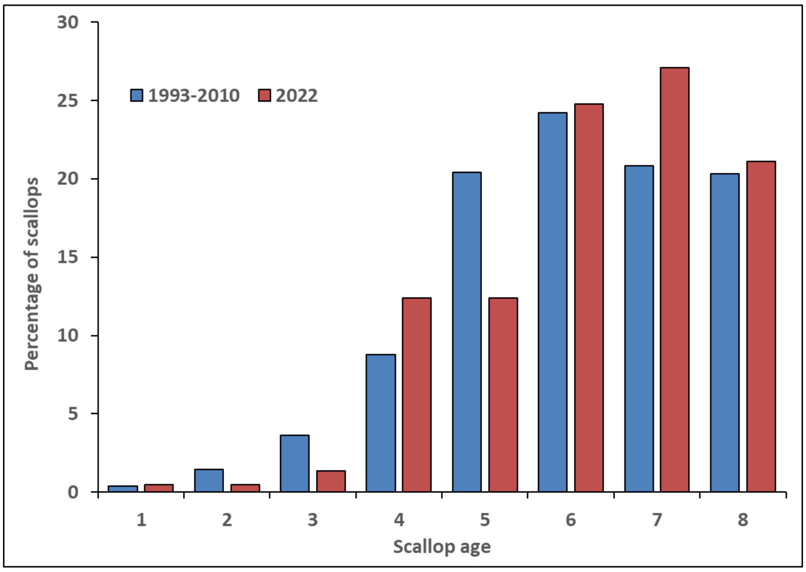


Figure 7. Percentage of each scallop age group of the sampled scallops (Pecten maximus) in the period 1993–2010 and 2022. Survey area was at Frøya in Trøndelag County (ICES assessment area 2a).

Data on individual diver catch per day (CPUE) was 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. The low and decreasing harvest rates since 2009 suggests that the stocks in Trøndelag are underfished and that there is a potential of increasing the commercial fishing activity without depleting the stocks.

The last IMR diving survey in the main commercial fishing area of Frøya/Hitra in Trøndelag County 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 (Nordland County). In 2019 to 2021 there was no survey activity due to lack of funding (2019) and Covid-19 (2020–2021). In June 2022 the first monitoring survey in Norhordland, Vestland County was conducted. Survey stations were selected based on the results from the National mapping program and from an evaluation of suitable scallop sea ranching areas in the late 1990s (Figure 8).

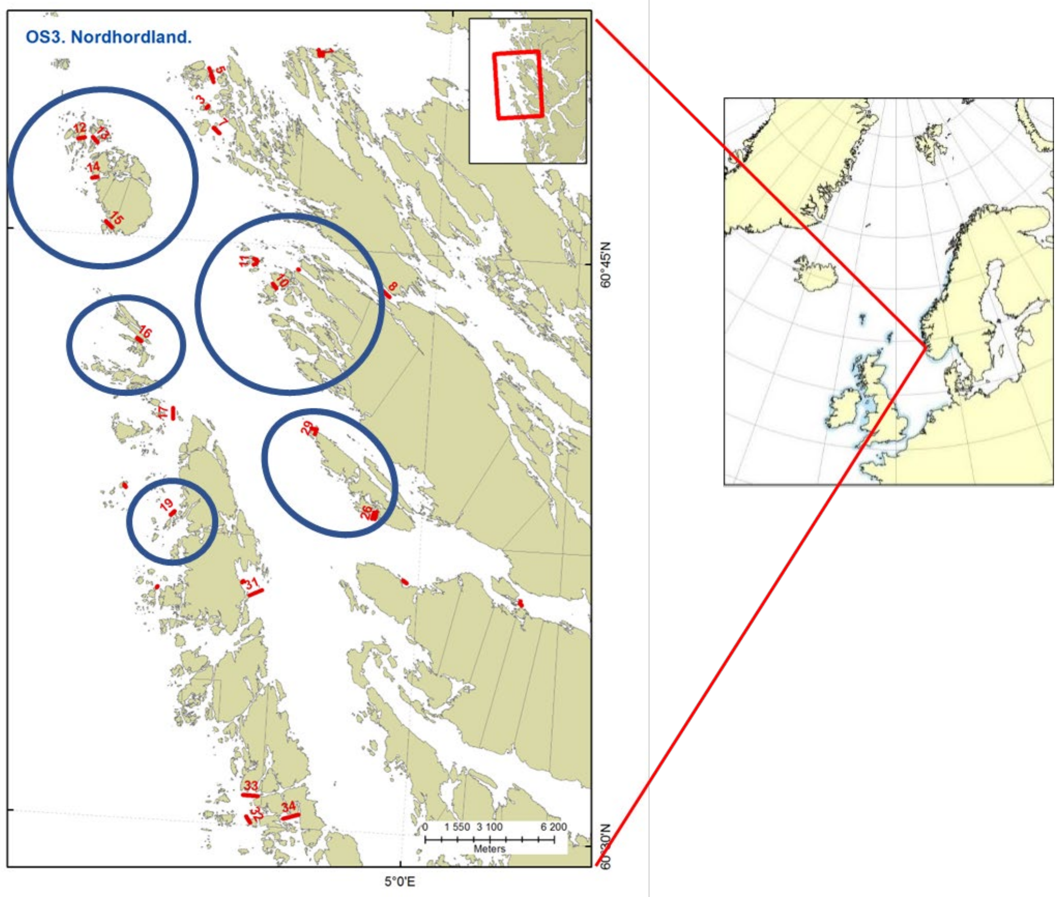


Figure 8. Area monitored during the 2023 scallop (Pecten maximus) survey in Nordhordland, Vestland County (ICES assessment area 4a).

Divers conducted underwater transects (7 dives) in addition to the traditional collection of scallops (10 dives). A 25-meter-long rope was placed on the seabed and the diver held a 1.5-meter-long pole in front while swimming slowly along the rope, sliding the pole from one side to another. The number of scallops within the 3x25 meter wide transect were counted, the habitat was described, and flora and fauna were recorded. On average, divers collected 13.6 scallops per sample dive and observed 0.74 scallops per transect dive (total of 31 transects). Compared to the results from the 2022-survey at Frøya/Hitra, densities in Nordhordland are low (0.1vs.0.01 respectively), confirming information from the National mapping program showing that the scallop populations in Vestland County have low densities compared to Trøndelag County. Scallop age distribution on the other hand was quite similar between the two areas, all year classes (age 2-8) being represented (Figure 9). Earlier studies have shown that populations in Western Norway in general may have very weak or missing age classes due to the high impact of the Norwegian coastal current, transporting water with low salinity from the Baltic combined with low winter temperatures. Since the early 2000, water temperature has increased along the Norwegian coast with an average of 1°C, resulting in shorter periods with cold water during winter, which may partly explain why all year classes are represented. Anecdotal information from recreational divers and skin divers suggests that *Pecten maximus* is more frequently found in shallow areas (< 10 m depth) and in greater numbers compared to earlier.

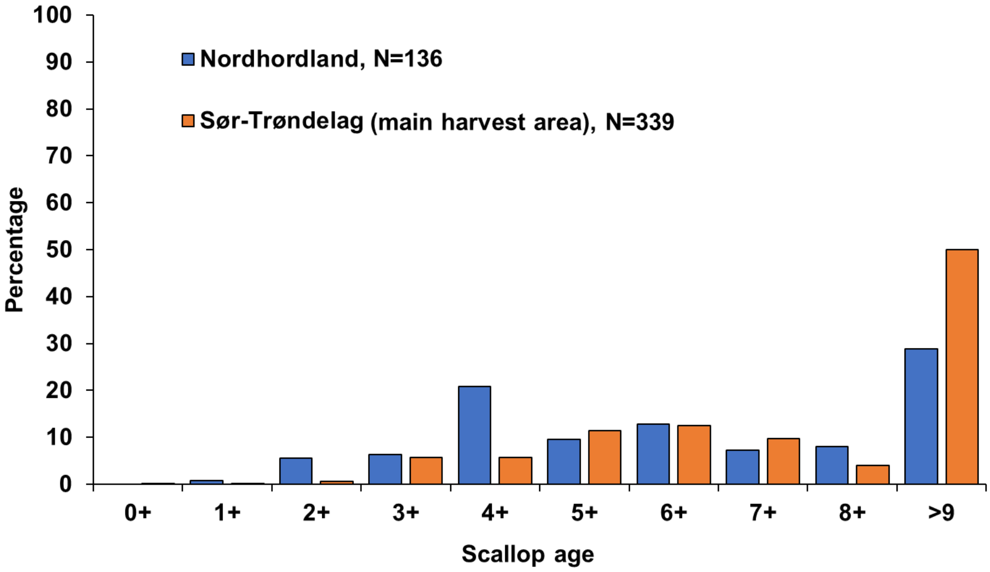


Figure 9. *Pecten maximus* age distribution in Nordhordland, Vestland County (ICES assessment area 4a) and Sør-Trøndelag, Trøndelag County (ICES assessment area 2a).

Norway update. Iceland scallop (*Chlamys islandica*)

After a substantial fishery for Iceland scallops in the Svalbard area in the late 1980s, the stock collapsed and the fishery was subsequently closed early 1990s. After conducting surveys around Bear Island and on Spitsbergen bank in 2019 and 2020, it was concluded that the stock has recovered and a MSY of 15 000 tonnes round weight for three major scallop beds was advised based on a data-limited MSE (Sundet & Zimmermann, 2020).

In connection with the development of new gear technology that has been shown to be less damaging to the benthic habitat than dredging and avoids therefore falling under the Norwegian dredge ban (Sundet *et al.*, 2019), a trial fishery with currently one active vessel has started in December 2022. The trial fishery will continue within 5 years and is regulated through a TAC based on the MSY quota advice, minimum landing size of 60 mm shell height, and comprehensive reporting requirements. Reported catches have reached 1600 tonnes round weight until August 2023. The reported data will be used to monitor the development of the fishery and establish a stock assessment and advice framework.

Following the opening of a trial fishery, a renewed interest to assess the state of the scallop beds north of Svalbard has increased. 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. In August 2022, IMR surveyed the area with 79 stations to assess the state and distribution of Iceland scallops, representing the first investigation in 30 years after the closing of the scallop. The survey was conducted primarily with video transects inside and outside the protected areas within the 12 NM zone. In addition, dredge stations were conducted outside the protected areas parallel to video transects to collect biological samples for size and age composition, and tissue samples for contaminant, nutrient and population genetic analysis. Parallel stations of both gear types also allowed to compare observed scallop densities. Still images were extracted from video to annotate scallops in the software DIVE, with repeated annotations of all stations by multiple persons to evaluate human bias in counting and its effect on density estimates and their uncertainty. The results of this analysis showed overall good alignment among counters, but revealed cases of relevant counter bias, particularly at station with high densities.

Iceland update. Iceland scallop (*Chlamys islandica*)

The main Iceland scallops (*Chlamys islandica*) beds in Breiðafjöður western Iceland were surveyed with a drop frame camera survey/mapping annually during 2014–2019. No surveys have been conducted since then, mainly because of budget constraints.

For the past three fishing years, 93 tonnes TAC was proposed on two grounds (Breiðasund and Hvammsfjörður) in the southern part of the fjord where abundance of scallop has been relatively stable. The advice for the fishing year of 2023–2024 was reduced by 20% to 75 tonnes as a precautionary measure due to the uncertainty regarding the stock status (Figure 10).

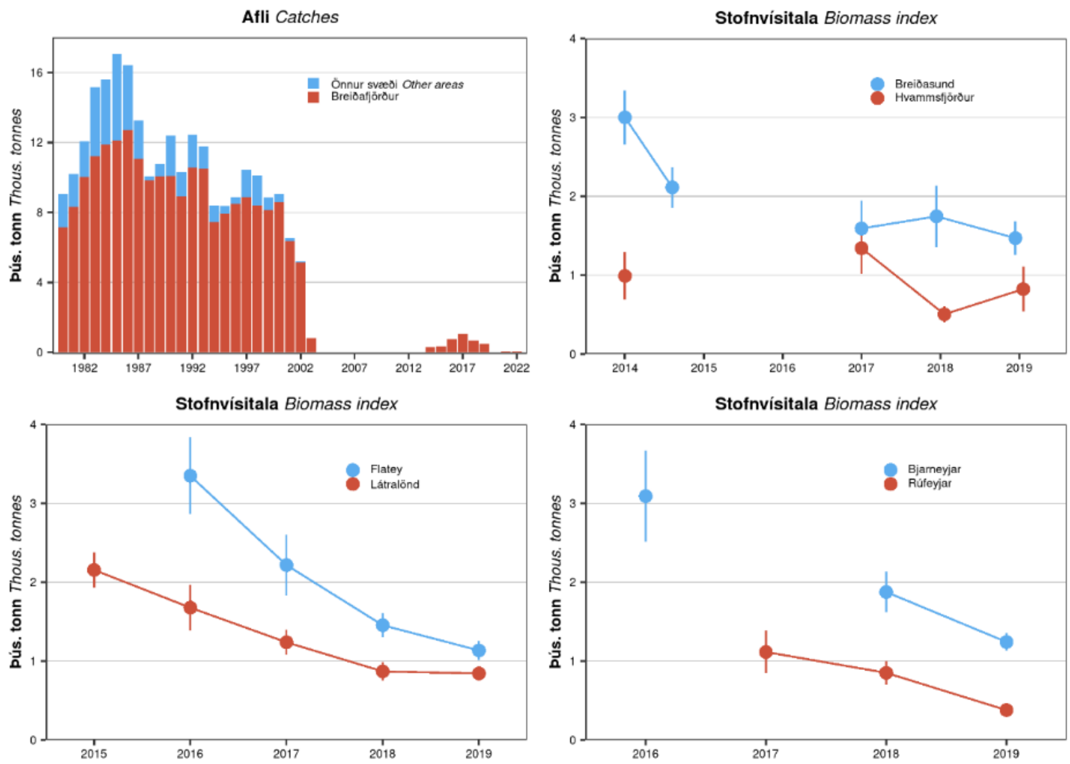


Figure 10. Catches from 1980–2022 and biomass indices on dredged grounds; in Breiðasund and Hvammsfjörður 2014–2019, Flatey area and Látralönd in 2015–2019, and Bjarneyjar and Rúfeyjar 2016–2019.

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

The drop camera survey of sea scallops on Georges Bank and in the Gulf of Maine, in the Western Atlantic, was conducted by the University of Massachusetts Dartmouth, School for Marine Science and Technology (SMAST) as planned in 2023. 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 into a length-based stock assessment model with forward projection capabilities run by NOAA. The SMAST survey was completed in six separate week-long trips using five different commercial scallop vessels (Figure 11). Survey stations followed a systematic grid design with stations 0.5, 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 drop was typically 50 m. 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.

The resulting spatial scallop densities were similar to the previous year in many areas, but some areas experienced increases and others decreases. Densities of small scallops (those less than 35 mm shell height) were lower than the previous year in most areas, although a large recruitment patch was detected in the Nantucket Lightship area on Georges Bank (Figure 12). These estimates were largely consistent with the data from the other two surveys.

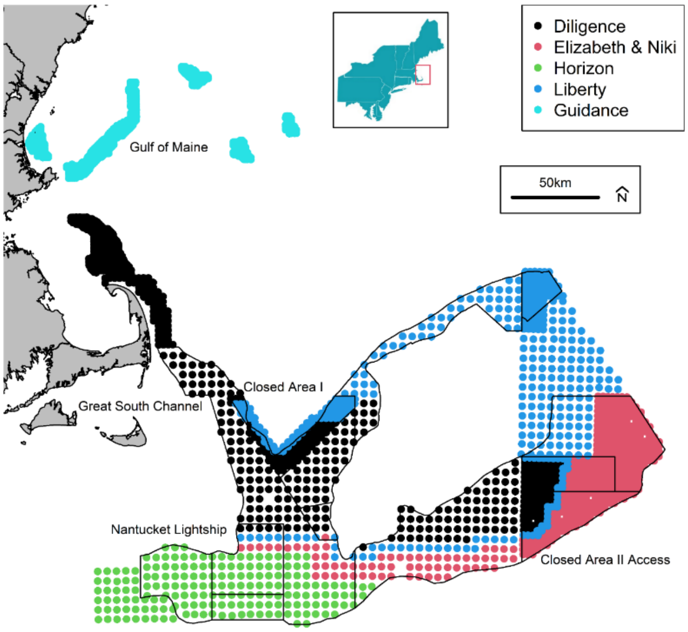


Figure 11. School for Marine Science and Technology Drop Camera Survey station locations by sampling vessel in 2023. Stations were attempted to be 5.6, 2.8, or 0.9 km apart depending on management requirements in specific areas. The land depicted in grey is the eastern coast of Massachusetts, USA.

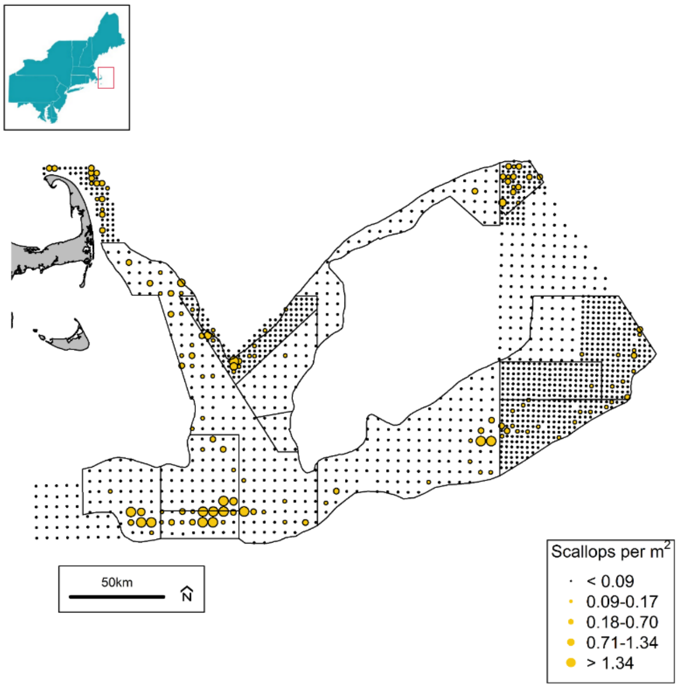


Figure 12. Mean prerecruit scallop density (scallops less than 35 mm shell height per m²) at each station from the 2023 School for Marine Science and Technology Drop Camera Survey on Georges Bank.

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

In 2022, official landings show that 393 tonnes of dredge caught scallops were landed by vessels fishing within NI waters (ICES rectangles 37E3, 37E4, 38E4, 39E3, 39E4). This is a decrease in landings from recent years, with 2022 landings the lowest recorded since 2010. Landings are down from a peak of 1,633 tonnes in 2014 (Figure 13). The majority of landings taken from NI waters in 2022 were landed by NI registered vessels (60%), with landings also taken by Scottish (26%), English (1%) and Isle of Man (13%) vessels.

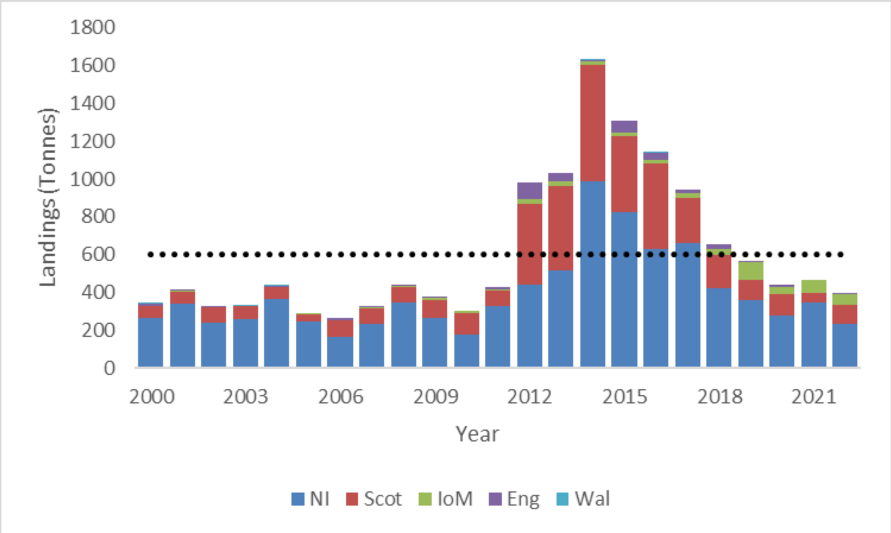


Figure 13. Landings of king scallops from NI waters (ICES rectangles 37E3, 37E4, 38E4, 39E3, 39E4), by vessel nationality. The dashed line indicates the average annual landings (602 tonnes).

Effort on the fishery is examined as the vessel power (in kilowatts) by the number of days active per trip (ideally the number of dredges fished during each trip would also be used when calculating effort, but this information is not available). Overall effort by vessels fishing for king scallops in NI waters showed an increasing trend between 2007 and 2015, peaking at 290,700 kwDays, but has since declined, with a total of 94,293 kwDays spent fishing scallops in 2022. The largest effort for king scallops tends to be in 37E4 and 38E4 (Figure 14). In 2022 effort placed on these two areas represented 70% of the total effort placed on the scallop fishery in NI waters.

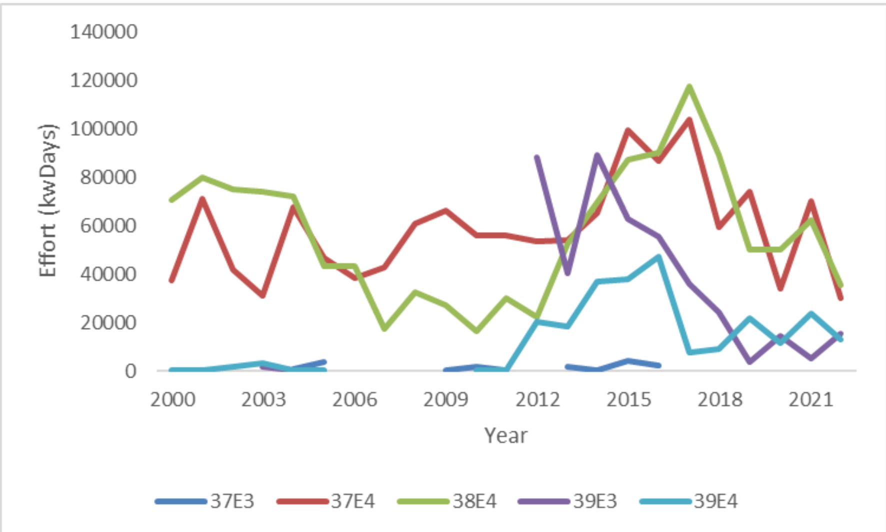


Figure 13. Total effort (kwDays) by vessels targeting scallops within NI waters. Effort is attributed to the ICES rectangle where the landings were made.

The average LPUE (kg/kwDay) showed an increasing trend up to a peak in 2014, before decreasing (Figure 15). From 2012–2022, ICES rectangle 39E4 has shown the greatest decrease going from having the highest LPUE (8.96 kg/KWDay) to the lowest (2.72 kg/KWDay). Rectangles 39E3 and 38E4 tend to have the highest LPUE over this period.

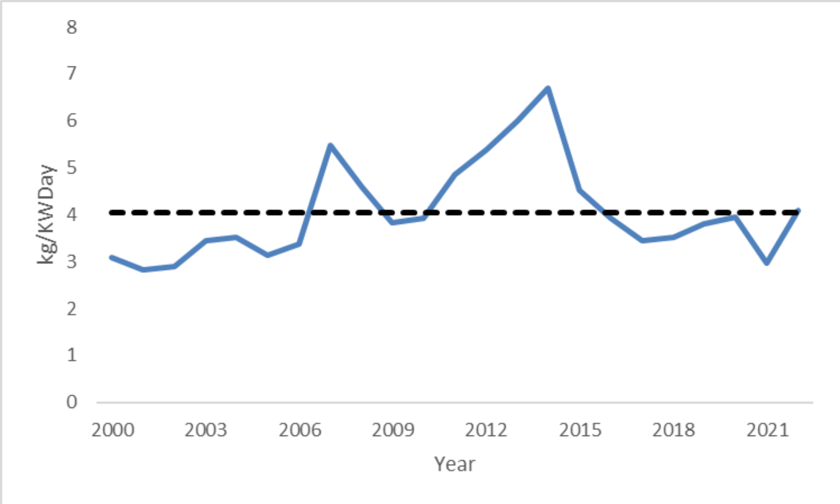


Figure 14. LPUE for king scallops landed from NI waters. The black dashed line represents the average LPUE over the analysed period.

AFBI carry out an annual scallop survey which covers NI waters. During the survey, which is a random stratified design, four 75-cm wide dredges, are used. A mesh liner is placed in one of the dredges to retain juvenile scallops and small bycatch. The dredges are towed for 30 minutes. The total catch is processed, with biologicals collected for individual scallops including age, total weight, length, breadth, gonad weight and muscle weight are recorded.

The number of scallops caught for each tow is recorded and, with a known distance of the tow, the catch can be standardised to give a CPUE as the number of scallops per 100m^2. The survey CPUE saw a large peak in 2012. However, when this peak is examined, it is driven by the introduction of the North coast to the survey areas (before this the survey was only carried out along the east coast of NI). The Irish Sea stations showed a peak in CPUE in 2014. Since both these peaks, average CPUE has shown a downward trend and, whilst the North Coast previously had a much higher CPUE, this difference is now reduced, with similar CPUE reported for the two areas in 2018 and 2020. In 2022, CPUE decreased in both the Irish Sea and North coast regions of NI waters (Figure 16).

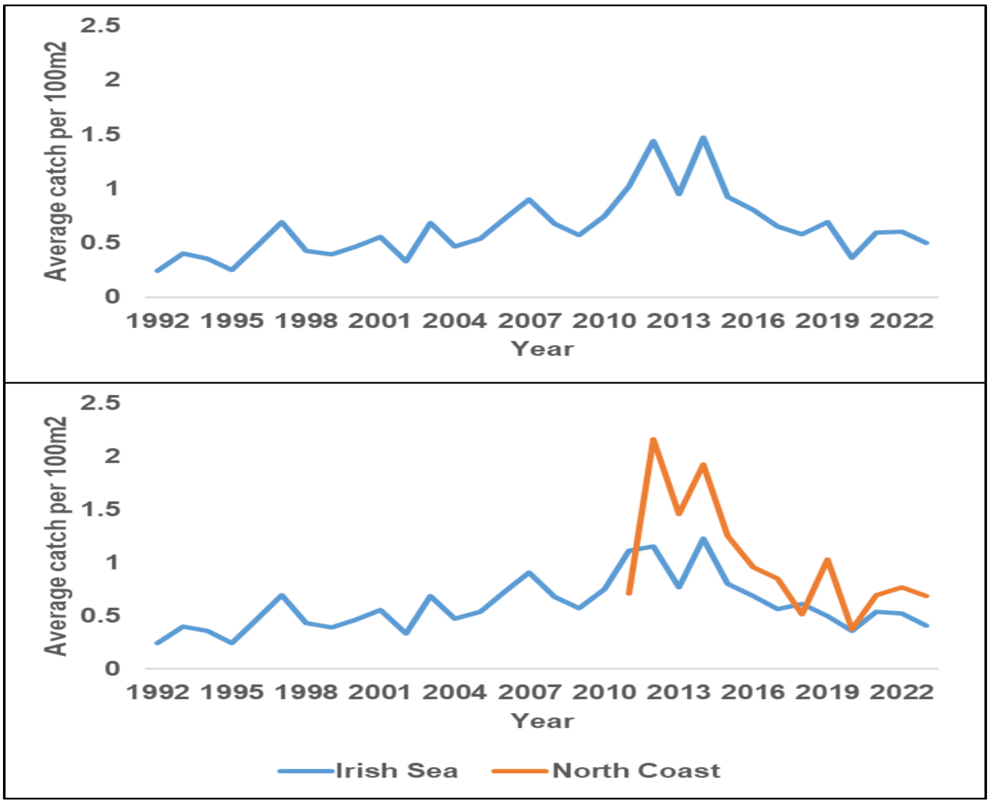


Figure 15. Survey CPUE for all survey areas pooled (top) and for the North Coast vs. Irish sea areas.

The reduction in scallops since the peak, has led to the NI scallop industry examining potential methods to try and enhance the scallop stocks in their waters. In 2017, an industry driven project, funded by Seafish, examined potential sites to be used for scallop enhancement. In 2020 a desk-top study was carried out to provide a review of potential scallop enhancement methods. In 2022 these sites were closed through legislation. A current larval dispersal model is being prepared to examine the potential locations of scallop beds which would benefit from the closure of these enhancement sites.

Northern Ireland update: Queen scallop (*Aequipecten opercularis*)

In 2022, 1,009 tonnes of queen scallops were landed by UK vessels fishing within NI waters (ICES rectangles 37E3, 37E4, 38E4, 39E3, 39E4). This is an increase in landings from recent years, but still below the 2012 peak of 6,581 tonnes (Figure 17). The majority of landings taken from NI waters in 2022 were landed by Scottish vessels (98.4%), with the remaining landings (1.6%) taken by NI registered vessels. In 2022, all landings of queen scallops by NI vessels were caught by trawl while all Scottish vessels caught their landings by dredge.

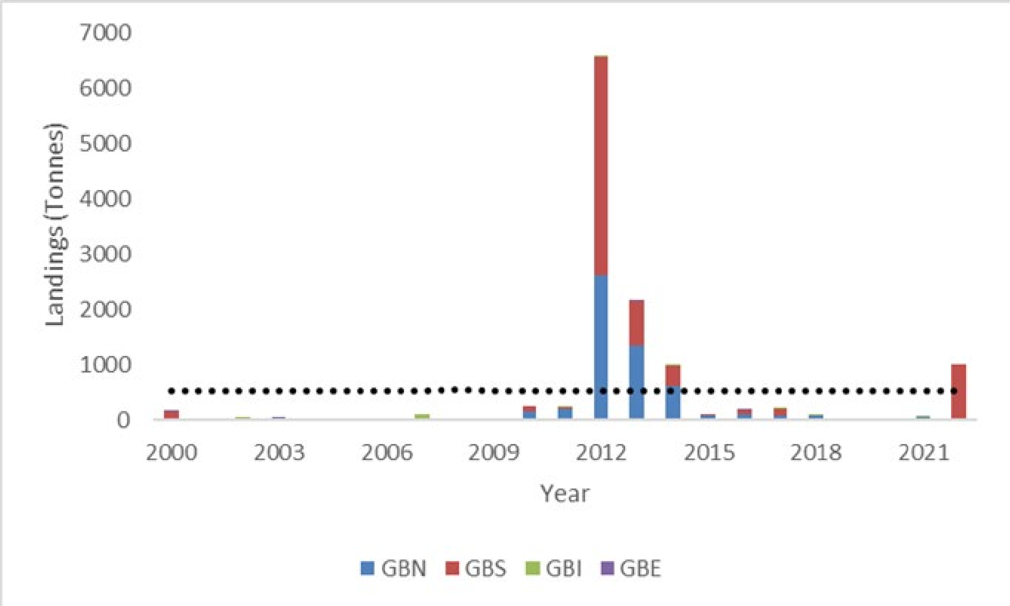


Figure 16. Landings of queen scallops from NI waters (ICES rectangles 37E3, 37E4, 38E4, 39E3, 39E4), by vessel nationality. The dashed line indicates the average annual landings.

The average LPUE (kg/kwDay) for queen scallops, shows an increasing trend up to a peak in 2011, before decreasing to 2020. In 2021, LPUE showed a small increase and in 2022 LPUE increased to its highest value of 54.6 kg/KWDays (Figure 18).

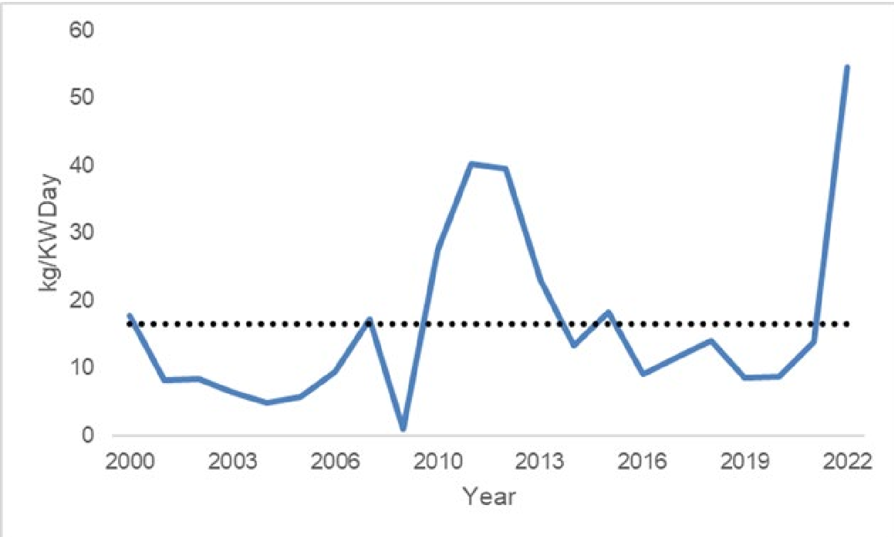


Figure 17. LPUE for queen scallops landed from NI waters. The black dashed line represents the average LPUE over the analysed period.

AFBI carry out an annual queen scallop survey which covers the ICES rectangles 39E3 and 40E3, along the NI north coast, and rectangles 36E5, 36E6 and 37E5 in the Irish Sea. During the survey, Under Water Towed Video (UWTV) is deployed at predetermined stations selected from a defined grid. The UWTV is towed for 15 minutes. The number of queen scallops displayed in the footage is counted by a minimum of two trained team members. Based on the counts, stations are selected for fishing. Stations are fished using either a queen scallop net or a tow bar fitted with two queen scallop dredges, a king scallop dredge and a king scallop dredge with a mesh liner. The total catch is processed, with biologicals collected for individual queen scallops including total weight, length, breadth, gonad weight and muscle weight recorded.

During the 2022 survey, 43 camera tows were carried out in the Irish Sea. The highest reported abundance of queen scallops was reported to the southeast of the Isle of Man. Eight trawl tows were completed. The greatest abundance of queen scallops caught was 82.97 queenies per 100 m². The length of queen scallops caught ranged from 33-85 mm with a peak at 60 mm. Very few queen scallops under 40mm were caught, with 99.4% of queen scallops being greater than the 40 mm MLS (Figure 19).

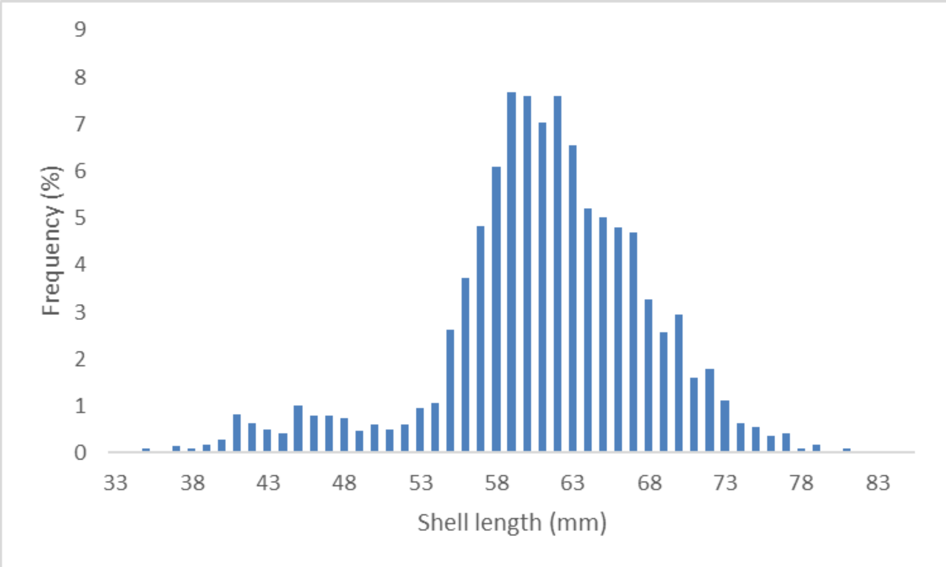


Figure 18. Length frequency of queen scallops caught in the Irish Sea, during the 2022 survey.

During the Irish Sea tows, 35 bycatch species were caught, with the lesser-spotted dogfish being the most abundant species caught, even over queen scallops.

Along the north coast of NI, 47 camera tows were completed. Whilst in 2021 the highest abundance as reported through UWTV was over 300 queen scallops per 100m², in 2022 this had decreased to 149 queen scallops per 100m². Ten trawl tows were completed in the area. The greatest abundance recorded was 76.23 queen scallops per 100 m². The length of queen scallops caught ranged from 25–82 mm, with a peak at 68 mm (Figure 20). Up to 10% of queen scallops made at the fished stations were under the MLS of 40mm.

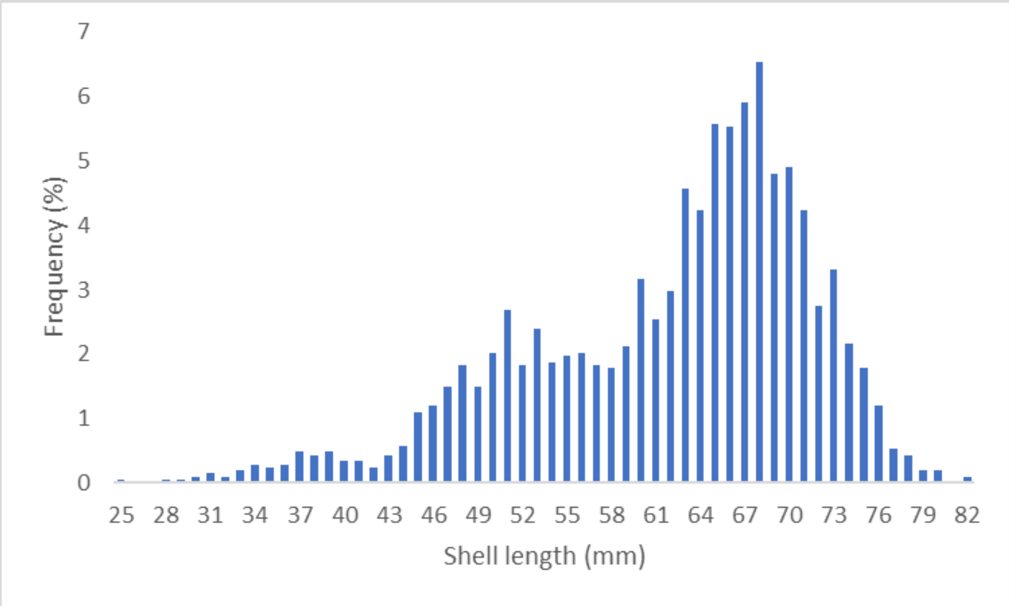


Figure 19. Length frequency of queen scallops caught along the NI north coast, during the 2022 survey.

Biomasses estimated from the survey show that while the Irish Sea has an improvement from the 2021 estimated biomass, along the north coast, there was a sharp decline (Figure 21). This decline in biomass may be due to the heavy fishing which occurred in the area in 2021.

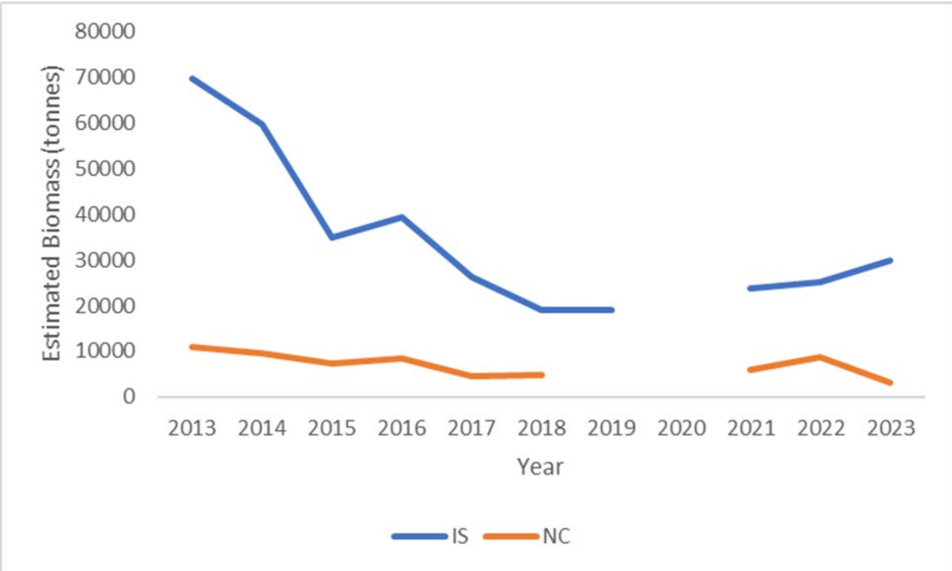


Figure 20. Estimated biomass for queen scallops in the Irish Sea (ICES rectangles 39E3 and 40E3) and NI north coast (rectangles 36E5, 36E6 and 37E5).

Isle of Man update: King scallop (*Pecten maximus*)

The Isle of Man currently operates two annual scallop surveys (assessing both king and queen scallops) both of which are undertaken in spring. A long-term (1992–2023) coarse-scale, fixed station survey is undertaken onboard a research vessel and a short-term (2019–2023), fine-scale, stratified random survey is undertaken by industry, in collaboration with scientists, onboard fishing vessels.

For king scallops, both surveys show very similar trends for 2023 and indicate good densities of post-recruits (scallops over MLS of 110 mm) spread among the main fishing grounds. Recruitment is strongest on the west coast at the Targets fishing ground. The abundance index, calculated from the research vessel survey, indicates an overall increase in scallops (all sizes combined) in 2023 compared to 2022 (Figure 22). In addition, the abundance index for 2023 (scallops of all sizes) calculated form the industry survey is the highest in the current time-series (i.e. from 2019). Following the ICES Category 3 data-limited approach the TAC for 2023/2024 king scallop fishing season has been set at 2179 tonnes (a 20% increase on 2022/2023 landings). The 2023/2024 Isle of Man king scallop fishing season will open on 1st November 2023.

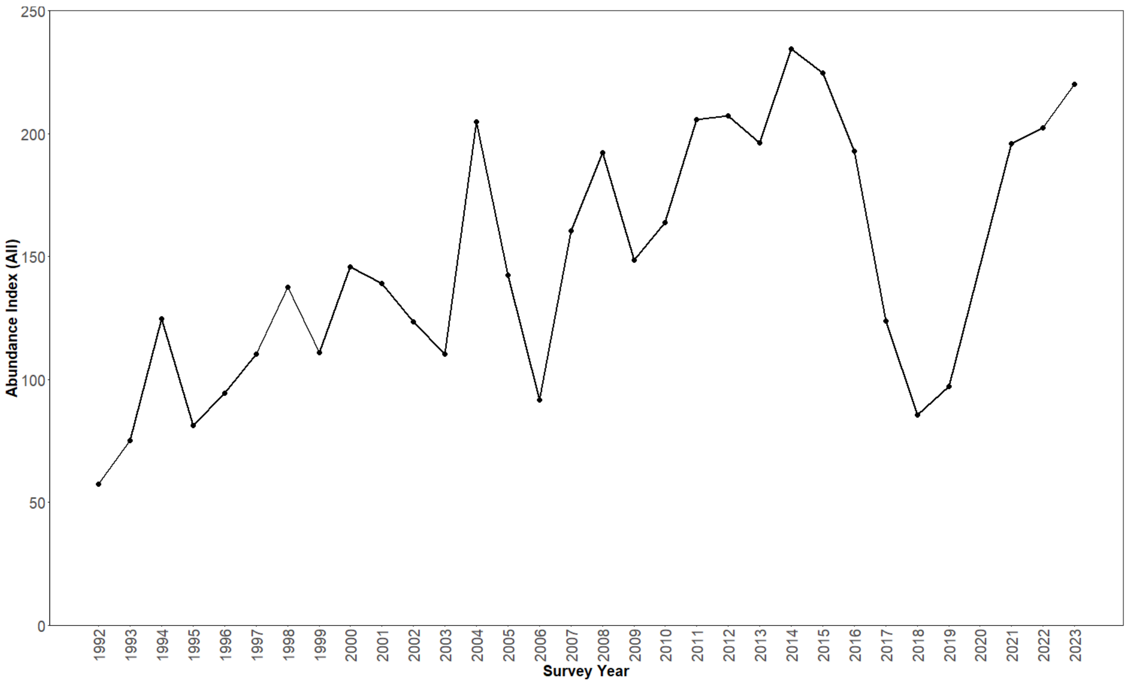


Figure 21. Abundance index for king scallops (all sizes) for Isle of Man territorial waters using data from the R.V. Prince Madog Annual Spring Scallop Survey.

Isle of Man update: Queen scallop (*Aequipecten opercularis*)

The Isle of Man currently operates two annual scallop surveys (assessing both king and queen scallops) both of which are undertaken in Spring. A long-term (1992–2023) coarse-scale, fixed station survey is undertaken onboard a research vessel and a short-term (2019–2023), fine-scale, stratified random survey is undertaken by industry, in collaboration with scientists, onboard fishing vessels.

For queen scallops, both surveys show very similar trends with the highest densities of both post-recruits (over 55 mm) and recruits (under 55 mm) recorded on the west coast of the Island, within the Targets fishing ground. The research survey data shows increases in both the recruit and post-recruit biomass for 2023 compared to 2022 (Figure 23). For recruits, biomass is the highest estimated value in the time-series since 2009. For post-recruits, biomass is the highest estimated since 2014. Similarly, the industry survey indicates a good level of recruits with above average recruitment densities at most sites on the west coast. For post-recruits the highest densities are also off the west coast at Targets. Following the ICES Category 3 data-limited approach the TAC for 2023 queen scallop fishing season was set at 1067 tonnes (a 20% increase on 2022 landings). There was no dredge fishery again for queen scallops in Isle of Man waters in 2023.

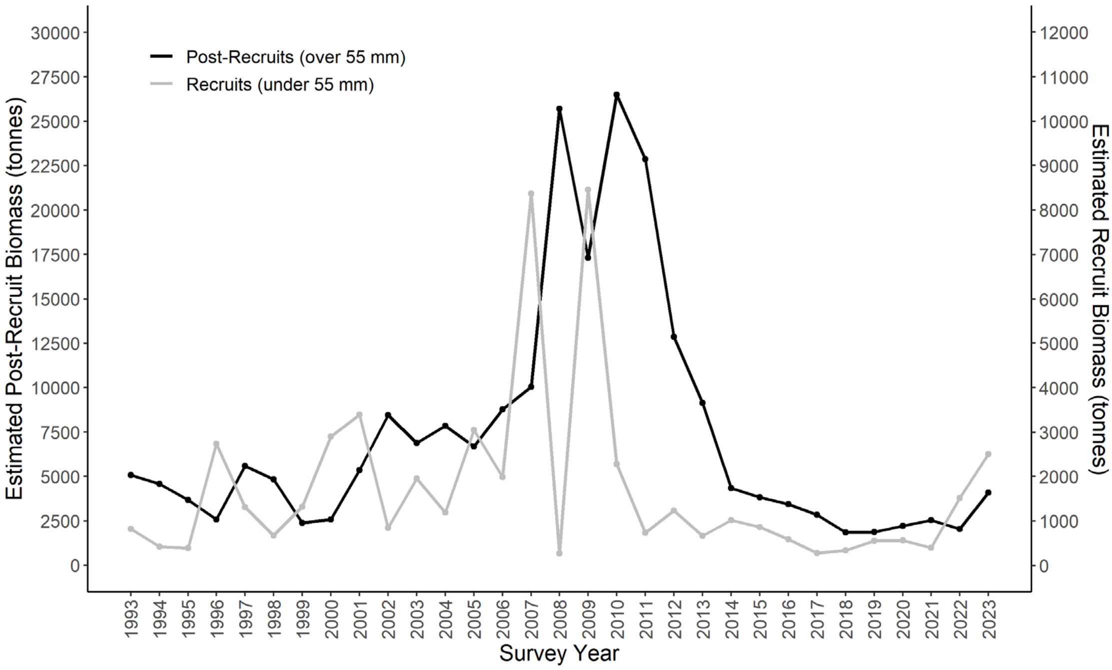


Figure 22. Estimated post-recruit (black line; left y axis) and recruit (grey line; right y axis) biomass for queen scallops within Isle of Man territorial waters using CSA.

Dredge surveys of the scallop grounds around Scotland have been carried out by Marine Directorate (formerly Marine Scotland Science (MSS)) since the mid-1990s (partial surveys of the west coast began in the late 1980s). There are currently four annual surveys which collectively cover the major scallop fishing grounds to the west of Scotland (including Clyde), the North Sea (Scottish coast) and around Shetland. The aim of the survey is to collect standardised catch rate data for king scallops for use in stock assessment (ToR b), but other objectives include collection of bycatch, contaminant testing, tissue samples for genetic testing, and recording marine litter (Table 4).

The scallop surveys have a fixed station design covering six assessment areas. There are 338 stations (Figure 24) but not all stations are surveyed because of time constraints, bad weather, aquaculture activity, closed areas and more recently windfarm activity. The station locations were originally determined with reference to British Geological Survey charts to locate suitable sediments and also using fishers knowledge of the fishing grounds. Stations are reviewed regularly and provide adequate coverage for the fished areas (based on comparison to fishing activity from maps of Vessel Monitoring data).

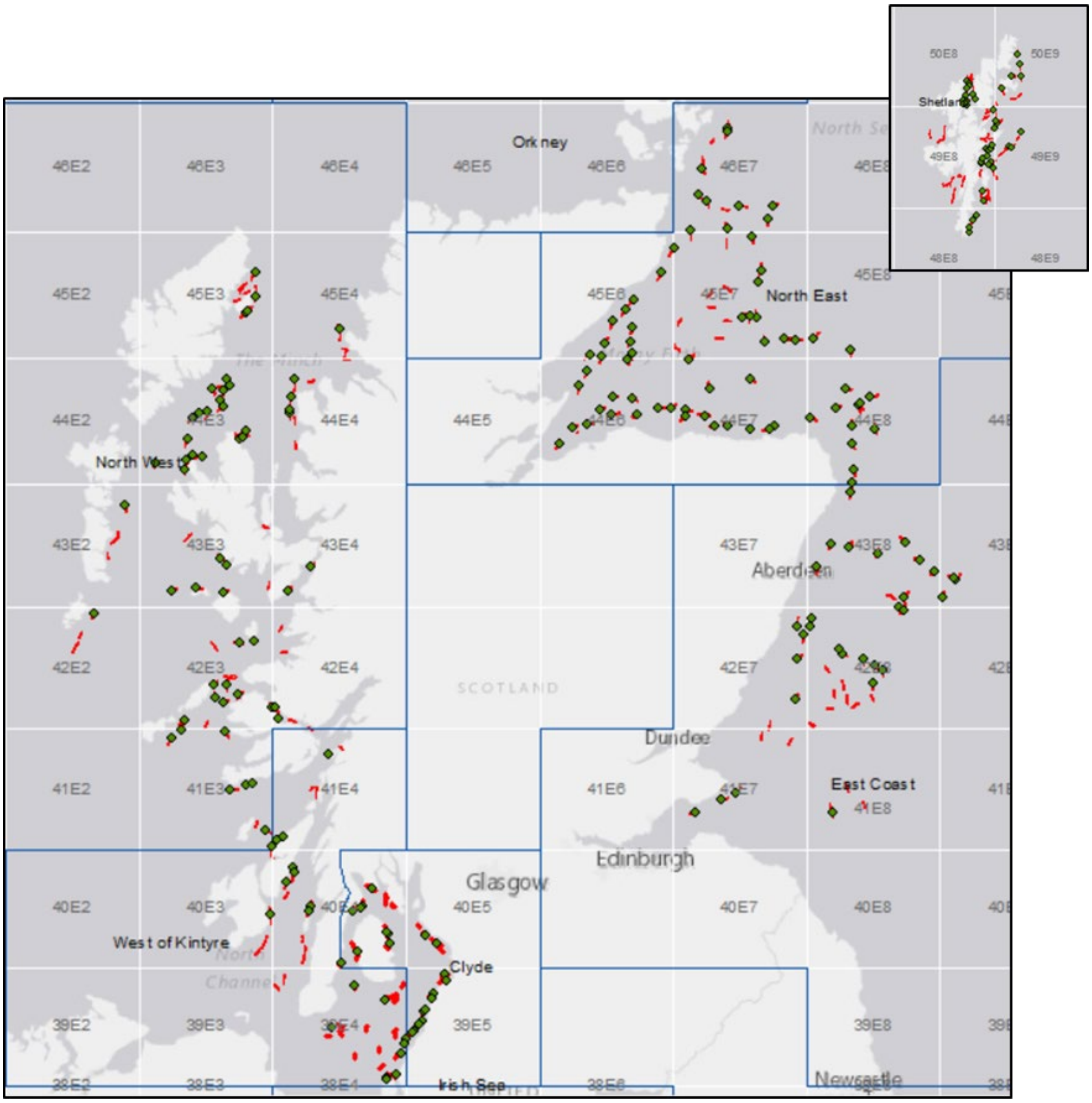


Figure 23. Map of Scotland showing mid points of fixed scallop survey stations in each of the assessment areas. Green are stations surveyed in 2023 (and Clyde 2022) and red are stations that were not surveyed.

Two dredge arrays are fished (one either side of the vessel). One array consists of standard commercial spring-loaded Newhaven type dredges (2.5′ wide, 9 tooth bar, with 80-mm internal diameter belly rings, fished from the starboard side). The second array consists of smaller configuration sampling dredges with 11 teeth and smaller diameter belly rings, more similar to commercial gear for queen scallops (*Aequipecten opercularis*) (2.5′ wide, 11 tooth bar, with 60-mm internal diameter belly rings, fished from the port side).

At each station the dredges are towed at a speed of about 2.5 knots for approximately 30 minutes with both sides of dredges on the seabed. All king scallops caught are aged and measured (length to the 0.5 cm below) in accordance with the standard operating procedures, and damage assessed in accordance with the damage index. The total width of dredges used in the survey has changed over the survey time-series. Catch rate data are therefore further standardised and expressed as numbers caught per hour per metre dredge width (N hr-1 m-1).

Since the last working group, four surveys with a total of 232 stations, covering all six of the assessment areas (Figure 24) were completed. The West of Kintyre had poor coverage due to storms during the survey, and the North East and East Coast was affected by creels and windfarm activity being situated at or near station locations. The west of Shetland was not covered due to the prevailing westerly winds.

On all surveys scallops caught were aged between two and 10 years old (note this is a plus group) however the size at age were noticeably larger for the two-year-olds in the Clyde and the East Coast. Bycatch, including starfish, are collected, identified, measured, sexed and damage assessed. The West Coast had lower numbers of bycatch but high numbers of starfish. Scallop survey reports are available from the British Oceanographic Data Centre ; Search the UK research cruise inventory (bodc.ac.uk)

Table 4. Summary of completed objectives for the Scotland scallop dredge surveys conducted since the last WGScallop meeting.

Objectives	**Clyde** **01/11/22 to 15/11/22**	**Shetland** **26/01/23 to 10/02/23**	**West Coast** **25/03/23 to 17/03/23**	**East Coast** **8/07/23 to 26/07/23**
Carry out a survey of scallop stocks	30 stations	41 stations	64 stations	97 stations
Age, measure and assess shell damage on all scallops caught	3057 scallops, 5 – 16 cm, age 2 – 10+ years	7985 scallops, 3.5 – 16.5 cm, age 2 – 10 years	11398 scallops, 3.5 – 16.5 cm, age 2 – 10+ years	11281 scallops, 5 – 16 cm, age 2 – 10+ years
Identify, quantify and damage assess bycatch (including starfish)	934 plus 2101 starfish	565 plus 3401 starfish	382 plus 3541 starfish	839 plus 2448 starfish
Collect whole scallops for heavy metal and organic contaminants testing	4 stations	4 stations	3 stations	4 stations
Collect scallops for genetic and shell isotope analysis to assess connectivity among scallop grounds in Shetland.	7 stations	6 stations	12 stations	Not required
Record and retain marine litter obtained during the dredging process for UK Marine Strategy	145 items	85 items	19 items	35 items
Report Link	Cruise inventory - FRV Alba Na Mara 1722A - cruise summary report (bodc.ac.uk)	Cruise inventory - FRV Alba Na Mara 0223A - cruise summary report (bodc.ac.uk)	Cruise inventory - FRV Alba Na Mara 0523A - cruise summary report (bodc.ac.uk)	Cruise inventory - FRV Alba Na Mara 1023A - cruise summary report (bodc.ac.uk)

Shetland update: King scallop (*Pecten maximus*)

Shellfish fisheries (including the dredge fishery for scallops) around Shetland are managed under a Regulating Order (The Shetland Islands Regulated Fishery (Scotland) Order 1999) by the Shetland Shellfish Management Organisation (SSMO). As a condition of the licences issued by the SSMO, fishermen are required to provide detailed records of landings and fishing effort. Scallop vessels within the 6-n.mile limit Shetland are limited to a maximum of ten dredges or overall length of 8.80 m in total and to fishing within the hours of 06:00 to 21:00.

SSMO logbook data have shown a steady increase in landings from 2000 onwards with a peak of 5.3 million scallops in 2022 (Figure 25).

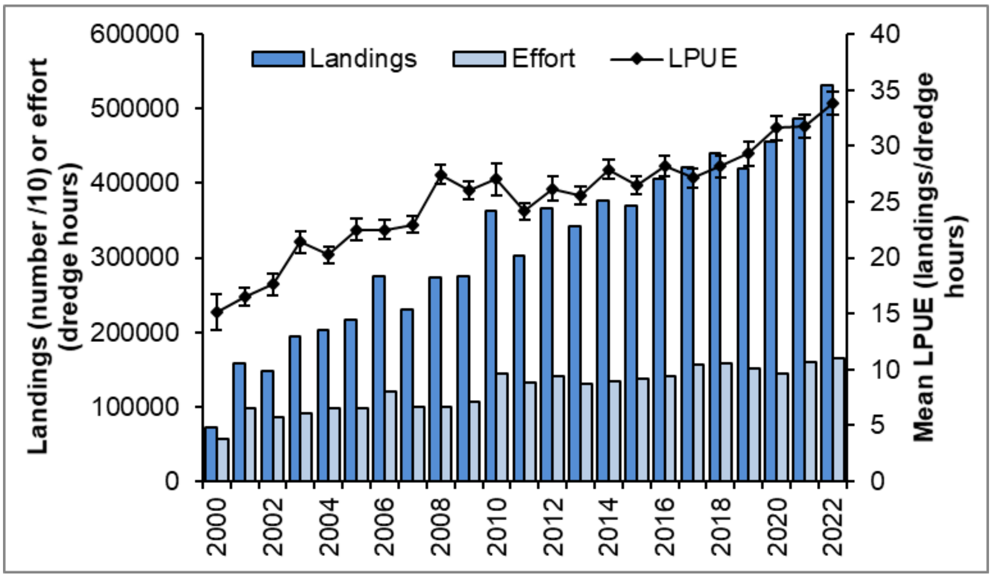


Figure 24. Landings of kind scallops (numbers x10), effort (number of hours by dredge), and means LPUE (number of scallops caught/hour towed by dredge) including 95% confidence intervals.

France, Bay of Saint-Brieuc update: 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 surface 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. This constraint did not impact the stock assessment in 2023.

The onboard operations usually undertaken in the late summer involve sampling 115 stations by dredging on constant distances of 200 m using an experimental dredge of 2m 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 the majority of 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 owing to previous references (Fifas and Berthou, 1999; Fifas *et al.*, 2004). Caught individuals are exhaustively aged and a LFD by age group and by tow is obtained.

The inshore King Scallop fishery of the Saint-Brieuc Bay is probably represented by the highest density levels in European scale. For the period 1962-2023, landings usually oscillated in a range of 4000–6000 tonnes with some extreme values as 12500 tonnes (season 1972/73) and 1300 tonnes (season 1989/90). The two last fishing seasons 2021/22 and 2022/23 are noticeable because of a steep increase of nominal landings compared to preceding ones (8031 tonnes and 8367 tonnes respectively). In recent years, the exploitation has been undertaken by 220–240 vessels (96–98% dredgers, 2–4% divers). Many historical stages throughout more than a half century of exploitation (from the early 60's onwards) show the vanguard position of this stock for the scallop French fisheries: 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).

Stock main indices are summarized in Figure 26. The adult biomass includes all age groups 2 and +, it provides an index of the potential fecundity of the stock. The exploitable biomass corresponds to individuals larger than 102 mm (MLS in VIIe French waters), thus it is a fraction of the adult one. Those indices show cyclical pattern with a downwards trend in the period 2006–2013 (respectively -53% and -57% for adult and exploitable biomass). Afterward, an increasing phase is obvious. Since 2018, the stock dynamics has steeply increased. In 2020-2022, the absolute records for adult and exploitable biomass were reached (respectively +54% and +43% between 2019 and 2020, +11% and +19% between 2020 and 2021, +24% and +5% between 2021 and 2022, +13% and +33% between 2022 and 2023).

The recruiting class abundance is estimated at 208 million, second highest historical value after 286 million of the last year (20020 tonnes vs. 24840 tonnes in 2022 although among them the immediately exploitable fraction increased: 4890 tonnes against 2160 tonnes in 2022, whereas 15800 tonnes should be exploitable in the middle of the fishing season 2023/24 under average individual growth rate i.e. January 2024 instead of 14450 tonnes a year ago.

The management policy serves to preserve more than one significantly abundant age groups with the aim of reducing fluctuations between yearly total abundance as more as possible independently of the annual recruitment variability. Four already harvested age groups are significantly abundant in the fishery: 3–6 years (respectively 25220 tonnes, 16020 tonnes, 11890 tonnes, 9560 tonnes). The total remaining biomass was estimated at 62690 tonnes (48830 tonnes in 2022, 43990 tonnes in 2021, 37050 tonnes in 2020 and 26930 tonnes in 2019). The cohort 2020 is represented by a total abundance of 197 million (against 163 million for the same age group a year ago), among them 76% reached the MLS=102 mm (20460 tonnes on a total biomass of 25220 tonnes).

In September 2023, the age group 1 was estimated equal to 248 million individuals (this abundance is expected to provide a total one of 114 in the 2024's survey accordingly to the relationship abundance GR2 vs. GR1 for a same cohort between two subsequent years). At the opposite of other stock indicators, this value is in regression compared to the three preceding cohorts 2019–2021 when the maximum historical level was reached year after year (respectively 417, 430 and 487 million). Although the currently assessed abundance for this age group remains high as it is the 6th higher value throughout the overall time-series. It is noticeable that the majority of historically high reproductions (threshold of 200 million) occurred in the period from 2015 onwards: 7 reproductions on 9 (apart from cohorts 2015 and 2018) against only 5 on 42 during the remaining time-series years 1973–2014).The year class abundances (2023–2025) are not yet known. The 2023's cohort abundance will be reliably estimated following summer 2024 as the spat collectors used in spring/summer 2023 have provided a minor part of explanation for the future class strength. The input values for the three cohorts 2023–2025 will be simulated. The simulation takes into account that Beverton & Holt S/R 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 1989–2022 (surveys 1990–2023) are assigned to probability levels against the spawning biomass[1] of the birth year (Table 5).

There are no other surveyed species or stocks in French fisheries with possibility of reliable projections on three years. The partnership of scientists/fishing industry (project FEAMP 28 on years 2017–2019 and 2020–2022) serves to guarantee the durability of the whole study. In this partnership, the survey at sea provides accurate estimates for GR1+ whereas the age-size structured stratified biological sampling on landings allows to calculate all fishing mortality components for GR2+ and the spat collectors for GR0 gives the first semi-quantitative estimate by cohort. After an intermediate funding scheme for 2023 (FEAMPA) in the basis of the same partnership, it should be judicious to ensure the continuity of the survey which has provided valuable tools for reliable and efficient development of stock management scenarios. In addition, the survey data has enabled the comprehension of the ecosystem processes as this King Scallop population is located near the southernmost limit for the species.

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

Table 5. Numerical application for the 2023/24 season's proposed quota. 1st column: proposed quota(tonnes); 2nd column: actual nominal landings (tonnes); 3rd column: Δf=% variation for fishing effort between 2022/23 and 2023/24; 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.

Option				Δf (%)	ΔY1 (%)	ΔY2 (%)	ΔY3 (%)	ΔBf1 (%)	ΔBf2 (%)	ΔBf3 (%)
Constant landings	p=0.5	7566	8367	-22.2	0.0	40.5	-8.2	-4.6	-9.0	-12.4
	p=Ψ(t)	7566	8367	-22.2	0.0	40.5	-8.4	-4.6	-7.7	-9.1
Spawning biomass near average 2020-23	p=0.5	7700	8492	-20.9	1.5	40.1	-8.5	-4.9	-9.3	-12.6
	p=Ψ(t)	8700	9412	-11.3	12.5	36.4	-10.8	-6.6	-9.8	-10.5
Landings variability minimized on 3 seasons	p=0.5	9050	9729	-8.0	16.3	35.2	-11.3	-7.2	-11.7	-14.3
	p=Ψ(t)	9000	9684	-8.5	15.7	35.3	-11.4	-7.1	-10.3	-10.8
Constant fishing effort	p=0.5	9875	10470	0.0	25.1	32.3	-12.9	-8.6	-13.1	-15.3
	p=Ψ(t)	9875	10470	0.0	25.1	32.3	-13.1	-8.6	-11.9	-11.8

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

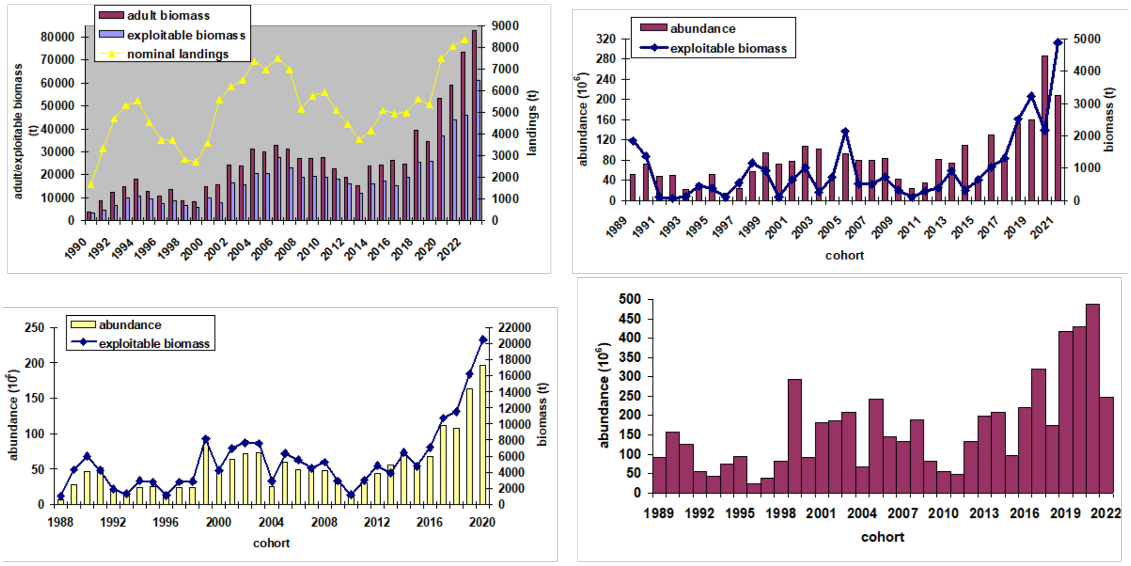


Figure 25. Saint-Brieuc Bay king scallop (1) Adult (yrs 2+) and exploitable biomass (≥102 mm), nominal landings. (2), (3) and (4) age group 2, 3 and 1 indices.

England update: King scallop (*Pecten maximus*)

In accordance with the established survey protocol, two dredge surveys using a commercial beam trawler were carried out in 2023. The first in May covered the western English Channel, and the second in September surveyed the eastern English Channel and parts of the North Sea coast of England. The area north of Cornwall could not be surveyed in 2023 due to poor weather conditions. An underwater towed video (UWTV) survey in the western English Channel was carried out in June 2023. Due to technical issues, only the eastern part of the primary survey area was completed, while all other areas were abandoned. Data from the 2023 surveys will be used in the next assessment, due to be published in April 2024.

Annual assessments have been presented to the working group since the programme started in 2017. The latest available report incorporates data from surveys carried out in 2022:

The report describes the 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, Food and Rural Affairs (Defra), and Seafish, a public body (sponsored by Defra) supporting the seafood industry in the UK.

In 2017, five stock assessment areas were identified as being of importance to UK fisheries (Figure 27): three in the western English Channel, ICES Division 27.7.e (Inshore Cornwall, I; Offshore, O; Lyme Bay, L) and two in the eastern English Channel, Division 27.7.d (North, N; South, S). In 2018 two additional areas were defined, one along the northern coast of Cornwall (27.7.f.I), and another along the Yorkshire/Durham coast (27.4.b.S). In 2021, a further assessment area, 27.4.b.D (Dogger Bank), 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 dredge surveys have not been carried out in that area since 2021.

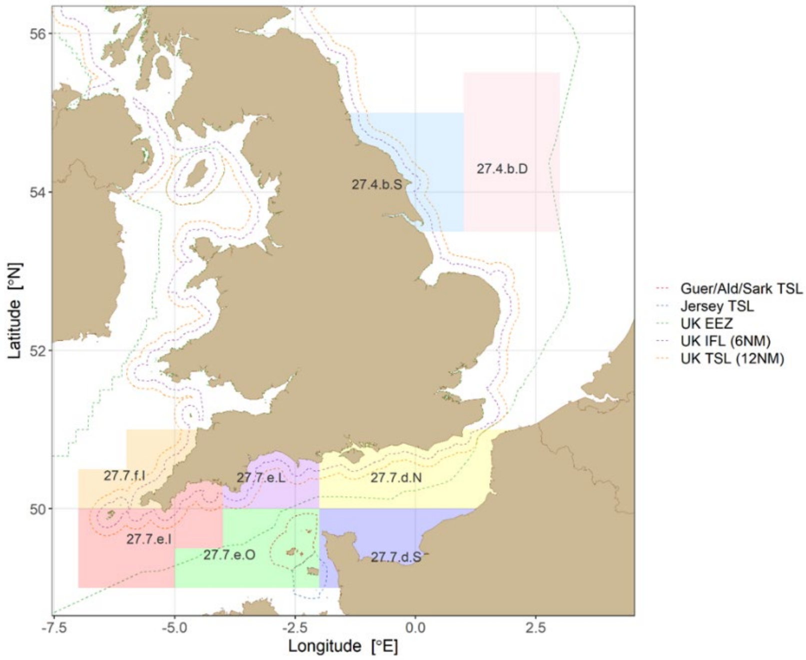


Figure 26. Stock assessment areas identified by the Centre for the Environment, Fisheries and Aquaculture Science (Cefas).

The segregation of assessment areas is based on regional differences in growth rates 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.

Dredge surveys in 2022 within the main fished beds of 7.d.N, 7.e.I, 7.e.L, 7.e.O, 7.f.I, and 4.b.S were used to estimate scallop biomass available to the dredge fishery. The scallop biomass in some un-dredged regions of assessment areas 7.e.I and 7.e.L was estimated from UWTV surveys in 2017, in 7.e.O, 7.f.I and 7.d.N in 2019, in 4.b.S and 4.b.D in 2021, and in 7.d.N and 7.d.S in 2022.

Harvestable biomass is calculated as the total live biomass for all king scallops at and above minimum landing size and in areas that are commercially exploited. For the 2022 assessment, international landings until and including 2021 were made available through the 2022 ICES WGScallop data call (Table 6). Harvest rates (international landings as the proportion of harvest-able biomass) are calculated using reported landings taken from the stock over the 12 months following each survey. The final 12-month periods for which harvest rates could therefore be estimated, based on the international landings reported to ICES in 2022, were May 2020 to April 2021 for assessment areas in Divisions 27.7.e and 27.7.f, and September 2020 to August 2021 for assessment areas in Divisions 27.4.b and 27.7.d. Harvest rates for 2021 are provisional estimates based on UK landings only.

Table 6. International landings of king scallops by assessment area and survey year, used to estimate harvest rates for Cefas stock assessments. Source: WGScallop data calls. 1 Survey year is defined as the 12-month period after each annual dredge survey, beginning in May for assessment areas in Divisions 27.7.e and 27.7.f, and beginning in September for assessment areas in Divisions 27.4.b and 27.7d.

Region	Assessment Area	Survey Year[1]	Landings (tonnes)
North Sea	27.4.b.S	2017	2186
		2018	2594
		2019	889
		2020	2450
		2021	1511
Eastern English Channel	27.7.d.N	2017	11260
		2018	14041
		2019	8429
		2020	11797
		2021	14201
Western English Channel	27.7.e.I	2017	2773
		2018	1507
		2019	1801
		2020	1309
		2021	1721
	27.7.e.L	2017	1450
		2018	2192
		2019	1284
		2020	2004
		2021	1763
	27.7.e.O	2017	956
		2018	1460
		2019	1868
		2020	2717
		2021	4560
Celtic Sea	27.7.f.I	2017	251

Region	Assessment Area	Survey Year[1]	Landings (tonnes)
		2018	135
		2019	395
		2020	187
		2021	112

Harvestable biomass density and below-minimum-size (BMS) number ratio at individual station locations of the 2022 dredge surveys are shown in Figure 28, Figure 29 and Figure 30. In the western English Channel (Figure 28) qualitatively the same spatial pattern existed as in previous years, with the highest biomass densities in the mid-Channel area to the west of Jersey, and a decreasing northward gradient into Lyme Bay. In the two westernmost scallop beds, and in the bed north of Cornwall, biomass densities were intermediate. The highest BMS number ratios were found in the mid-Channel area and in Lyme Bay. In the eastern English Channel (Figure 29), harvestable biomass densities decreased compared with 2021. However, the BMS number ratio increased, especially in the northwestern part of the scallop bed, indicating potentially strong recruitment for the following year. In the Yorkshire/Durham assessment area (Figure 30), harvestable biomass density increased compared with 2021. However, this increase was due to growth (ageing) of the adult population, rather than from significant new recruitment. The BMS number ratio continued to decline, indicating that unless a strong pulse of juveniles is observed within the next few years, the population may become overfished.

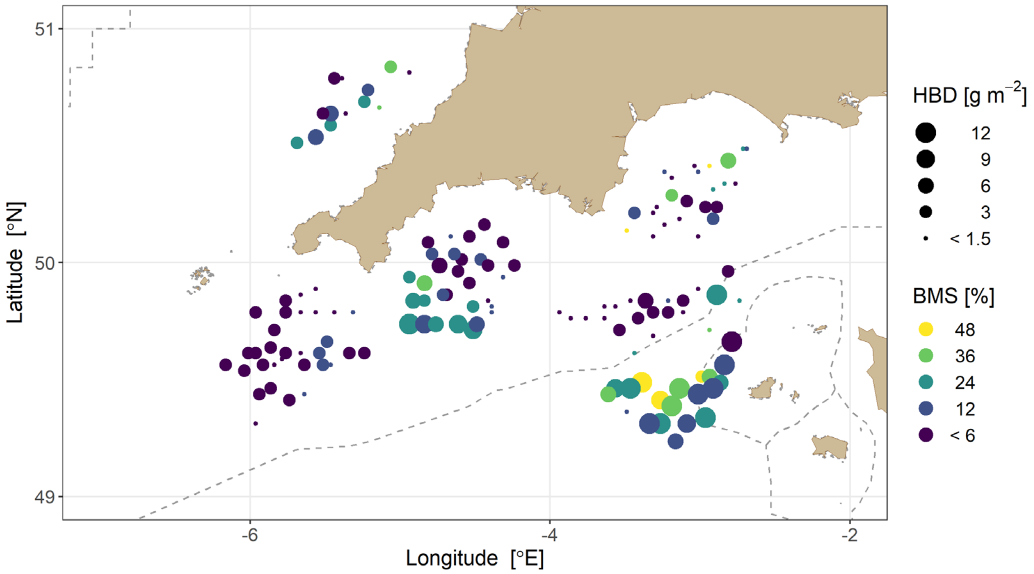


Figure 27. Harvestable biomass density (HBD) and below-minimum-size (BMS) number ratio at individual station locations - Western English Channel and Celtic Sea (May 2022 dredge survey).

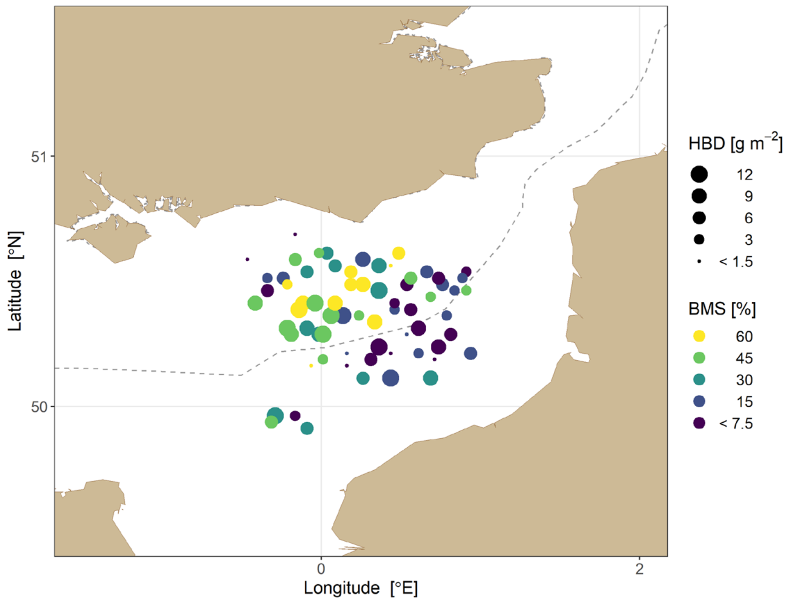


Figure 28. Harvestable biomass density (HBD) and below-minimum-size (BMS) number ratio at individual station locations - Eastern English Channel (September 2022 dredge survey).

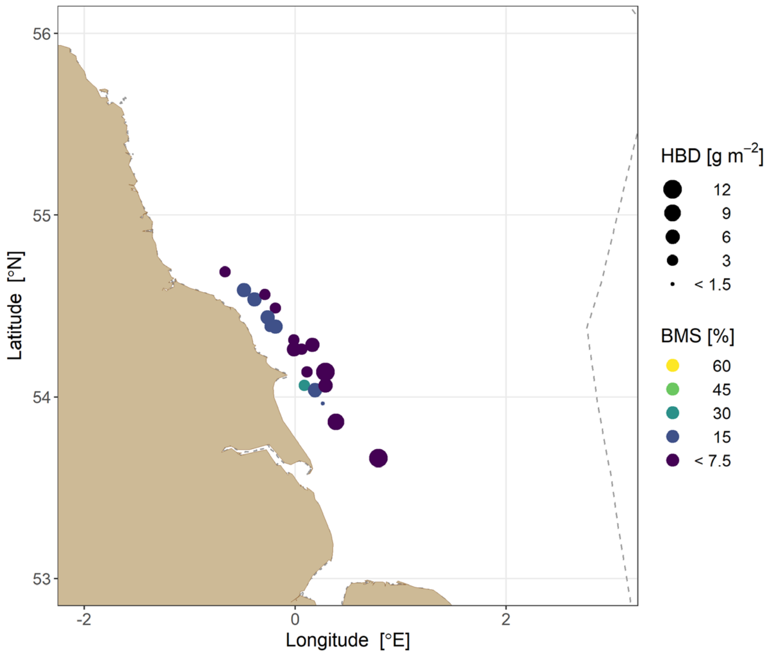


Figure 29. Harvestable biomass density (HBD) and below-minimum-size (BMS) number ratio at individual station locations - North Sea (September 2022 dredge survey).

Total harvestable biomass by assessment area is shown in Figure 31. In most of the assessment areas, the harvestable biomass density increased compared with 2021. In the assessment area north of Cornwall, surveying in 2021 was prevented due to poor weather conditions. In comparison with 2020, the harvestable biomass in that area increased in 2022. As mentioned above, the only area with a decreasing total harvestable biomass is the northern part of the eastern English Channel.

In all assessment areas (except for the area north of Cornwall, for which harvest rates in 2021 cannot be determined due to the lack of survey data), harvest rates increased from 2020 to 2021 (Figure 32). Despite that, in the western English Channel Inshore and Offshore assessment areas, harvest rates in 2021 remained below the area-specific MSY-proxy (Figure 33). In the eastern English Channel, the harvest rate in 2021 was at the MSY-proxy. In the Yorkshire/Durham assessment area, and especially in Lyme Bay (western English Channel), harvest rates remained above the MSY-proxy.

For more detailed results and a description of the methodology (including the MSY calculations) see the latest assessment report.

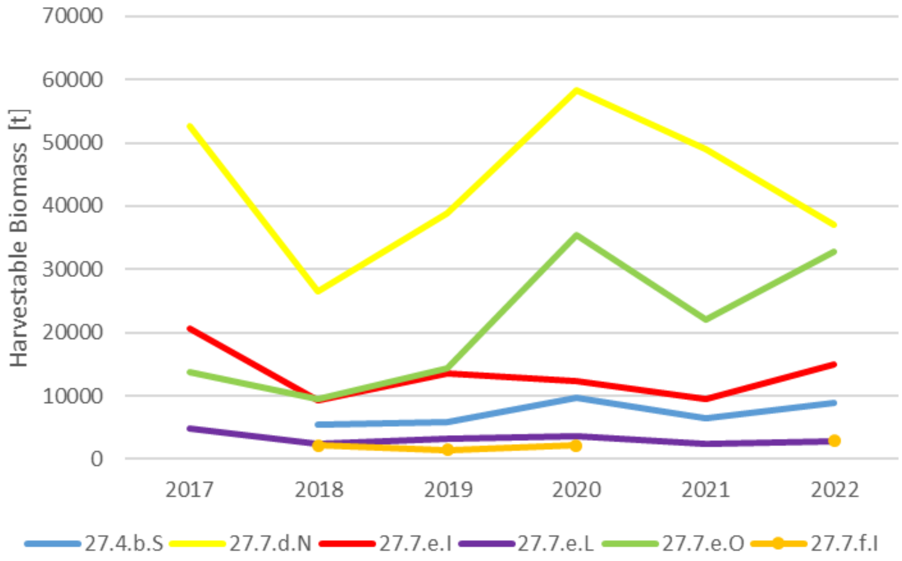


Figure 30. Harvestable biomass by assessment area.

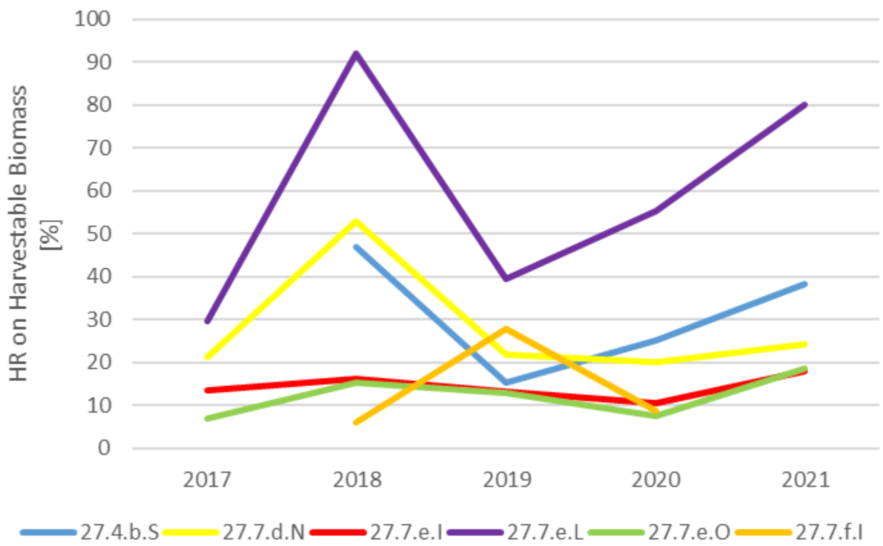


Figure 31. Harvest rate (HR) by assessment area.

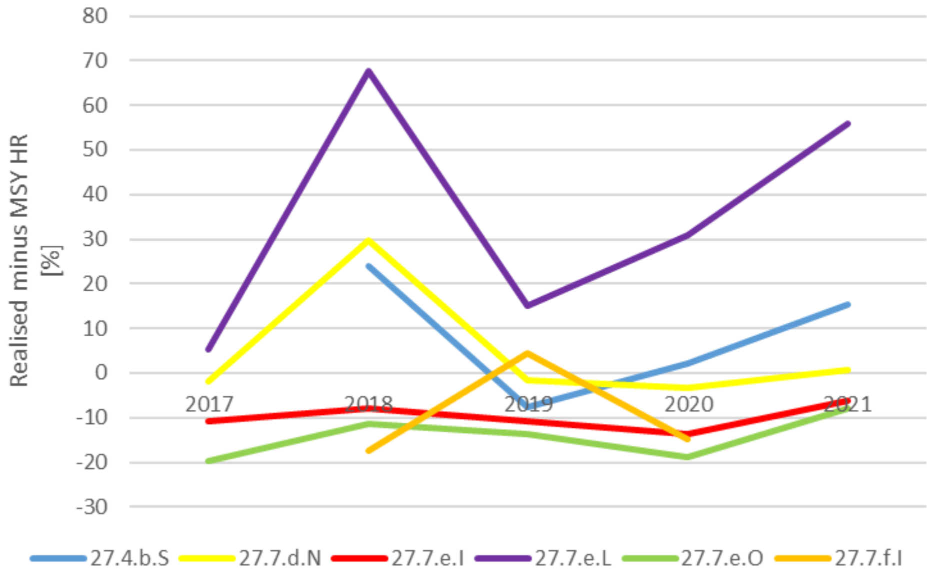


Figure 32. Residual harvest rates (realised – MSY-proxy) by assessment area.

Wales update: King scallop (*Pecten maximus*)

An annual fishery-independent survey has been conducted in Welsh waters since 2012, except for 2015. The survey is conducted from the RV Prince Madog and consists of 4 scallop dredges; 2 "queen" dredges (60 mm ring size) and 2 "king" dredges (80 mm ring size). Tows are 20 minutes. Up to 2022 stations had been randomly spatially allocated within each survey location (North – Liverpool Bay, North Llyn Peninsula and Cardigan Bay). In 2023 the previous 10 years' worth of data on density estimates were used to estimate the variance in density in different management strata. This variance was then used to allocate the total sampling effort through a Neyman Allocation approach (Figure 34).

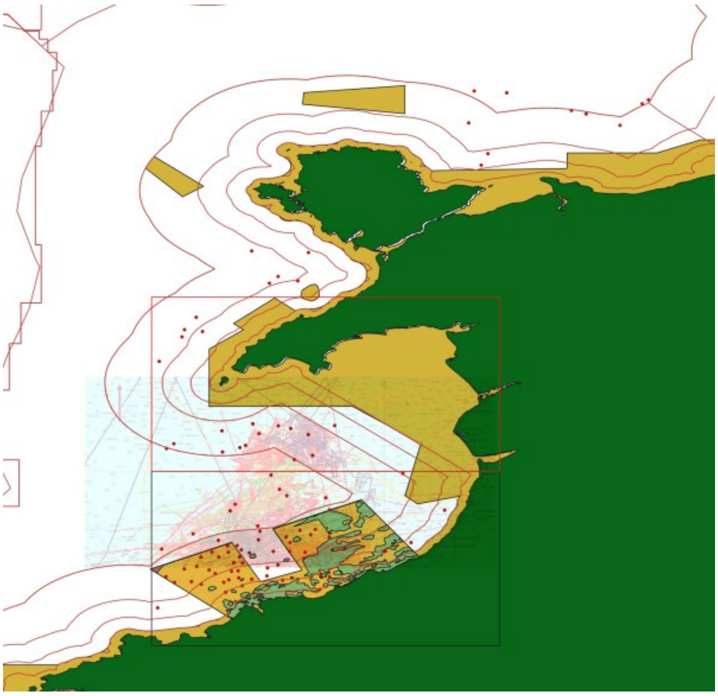


Figure 33. 2023 sampling station for the annual fishery independent scallop survey in Welsh waters. Yellow indicates areas closed to scallop dredging.

Liverpool Bay, north of the Llyn Peninsula and parts of Cardigan Bay are open to scallop dredging, whilst there is an area within Cardigan Bay that is closed to dredging and has been since 2009 (Figure 34). The primary fishery takes place within Cardigan Bay.

The abundance of scallops caught at each station were converted to densities using area swept from the tow coordinates. These densities are uncorrected for catchability of the dredges (Table 7).

Table 6. Densities of scallops caught in king and queen dredges in the annual fishery-independent scallop survey in Welsh waters. Densities represent the number per 100 m² but are not corrected for dredge catchability.

	Liverpool	Llyn	Open Box	Open other	Exp	SAC East	SAC West
King Dredge							
2012	0.30	0.16	1.57	0.96	4.56		4.98
2013	0.26	0.23	2.17	0.78	5.88	5.93	2.21
2014	0.27	0.24	1.05	0.79	2.13	1.27	1.15
2016	0.03	0.07	0.31	0.21	1.20	0.75	0.39
2017	0.13	0.73	0.38	0.16	2.92	1.08	
2018			0.66	0.16	4.70	0.66	1.47
2019	0.37	0.48	3.32	0.28	8.87	1.11	1.39
2020	0.34		1.47	0.84	10.55	1.01	5.01
2021	0.51	0.03	2.06	0.82	13.95	0.07	2.74
2022	0.51	0.11	3.34	0.62	19.39	1.99	3.16
Queen Dredge							
2012	0.38	0.24	2.49	1.02	4.62		5.99
2013	0.40	0.26	4.76	1.53	8.28	6.35	4.80
2014	0.46	0.44	1.27	1.16	3.31	2.52	1.59
2016	0.06	0.20	1.45	0.64	4.53	2.18	1.83
2017	0.21	0.60	0.90	0.26	4.39	2.99	
2018			3.85	0.20	8.58	0.97	3.33
2019	0.41	0.44	4.45	0.41	9.03	1.11	1.33
2020	0.76		2.06	2.06	14.48	1.53	9.68
2021	1.72	0.15	2.95	1.26	13.53	0.10	4.09
2022	0.56	0.16	4.64	0.74	23.73	2.30	3.75

Densities of scallops in parts of the closed area of Cardigan Bay "(Experimental box" (Exp)) have been increasing steadily in recent years although other parts of the closed Special Area of Conservation (SAC) remain at low density (Figure 35).

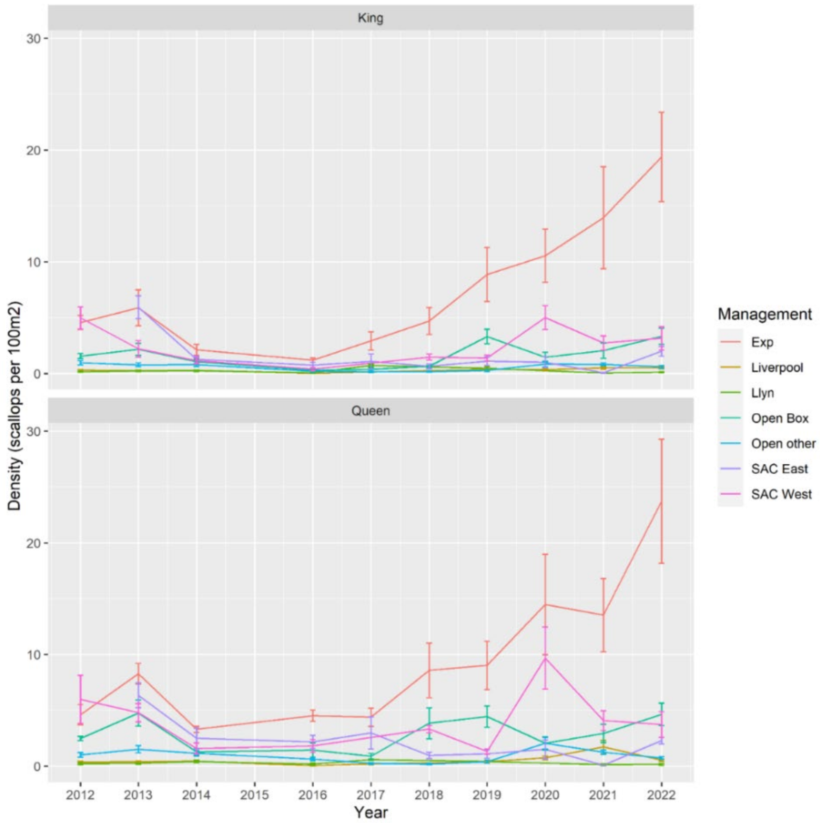


Figure 34. Density of scallops caught in two different dredge types in the annual fishery-independent scallop survey in Welsh waters. Densities are number caught per 100m^2 and are uncorrected for dredge catchability.

Size at maturity has been estimated for scallops in Wales in Liverpool Bay (L50 = 95 mm) and Cardigan Bay (L50 = 87 mm). Estimates were made using gonad maturity staging data from late summer and autumn surveys whereby any scallops with gonads with an observation index of 3 or greater was considered mature (Figure 36).

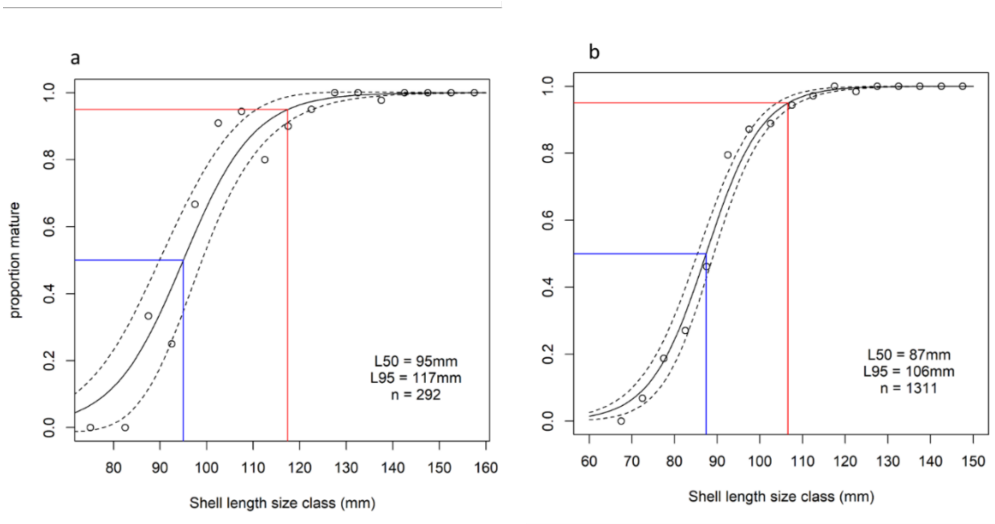


Figure 35. Maturity ogives for king scallop in a) Liverpool Bay and b) Cardigan Bay in Welsh waters. Blue lines show L50 and red line L95.

Growth estimated via Von Bertalanffy Growth functions varied between sites and areas within Cardigan Bay (Figure 37). Various life-history parameters for Welsh King scallops are shown in Table 8.

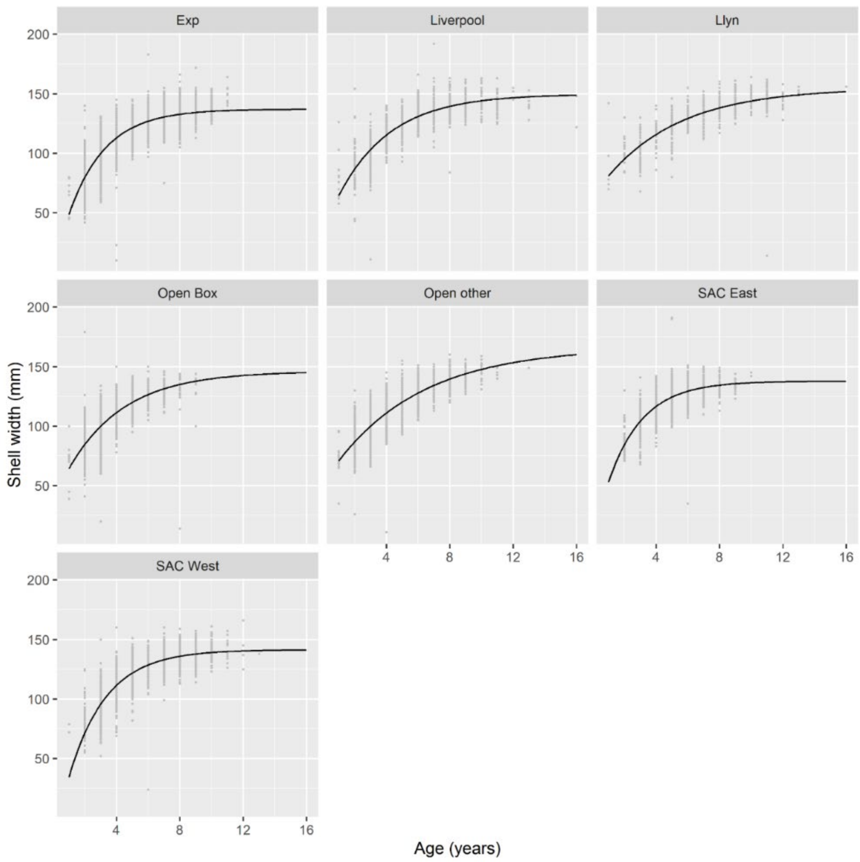


Figure 36. Von Bertalanffy Growth curves for scallops in different areas of Welsh waters.

Table 7. Life-history parameters for the king scallop in different areas of Welsh waters

Management	Linf	k	t0	wbeta	walpha	L50	L95
Liverpool	149.7	0.30	-0.87	2.65	0.0005	95	117.4
Llyn	154.9	0.21	-2.50	2.40	0.0020	NA	NA
Open Box	146.1	0.29	-1.04	2.68	0.0005	87.4	106.6
Open other	166.4	0.18	-2.07	2.58	0.0008	87.4	106.6
SAC West	141.4	0.42	0.34	2.65	0.0006	87.4	106.6
Exp	137.1	0.43	-0.01	2.63	0.0006	87.4	106.6
SAC East	137.8	0.46	-0.06	2.48	0.0013	87.4	106.6

Jersey, Channel Islands update: King scallop (*Pecten maximus*)

The third year of Fishery-independent scallop sampling has taken place using the same methods as per those reported in WG SCALLOP 2022 report. Data analysis will be conducted over winter of 2023 including, for the first time, the aging of a sub sample of shells. In addition, a dive survey trial was conducted in partnership with Blue Marine Foundation to attempt a stock assessment comparison between areas open to dredging and areas within the no dredging MPA network. The dive survey was based on a simplification of the methods used for scallop surveys in Norway (Figure 38).

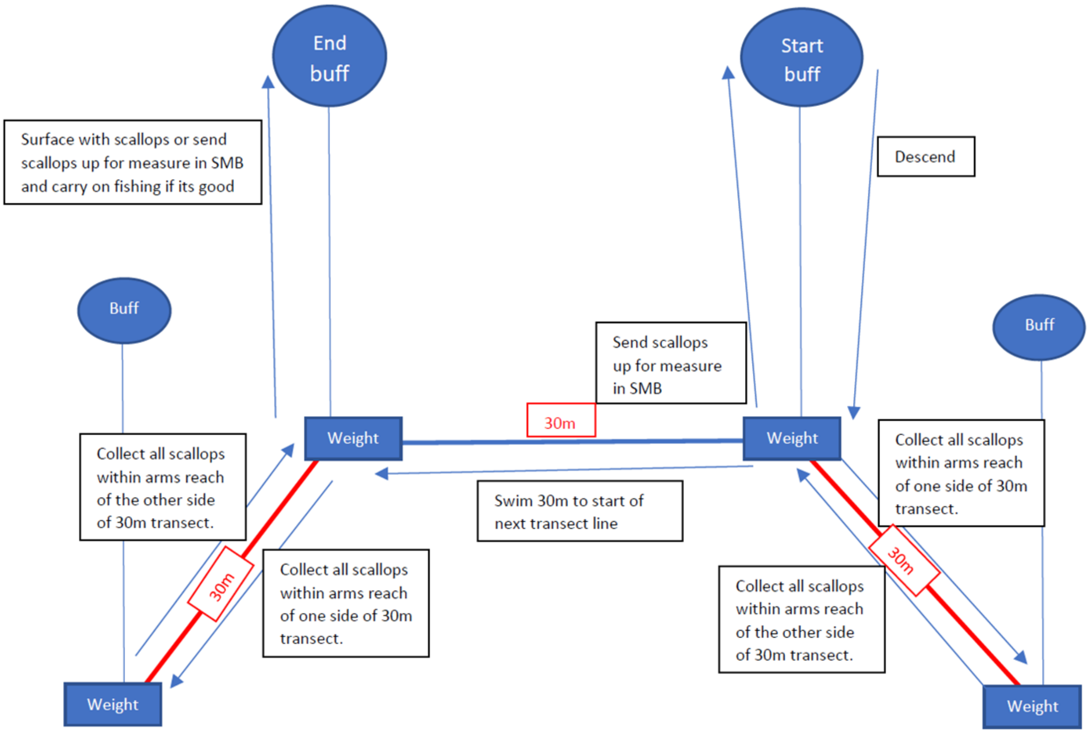


Figure 37. Scallop dive survey methodology used in Jersey.

Jersey reported on annual fishing effort and catches by Jersey based vessels. From 2023 Jersey will be able to report on the Jersey licensed French dredging fleet that operates in its waters. 2022 showed consistent landings for the dive fishery with increasing landing for the dredge fishery supported by new export markets. LPUE for both sectors has strengthened (Figure 39).

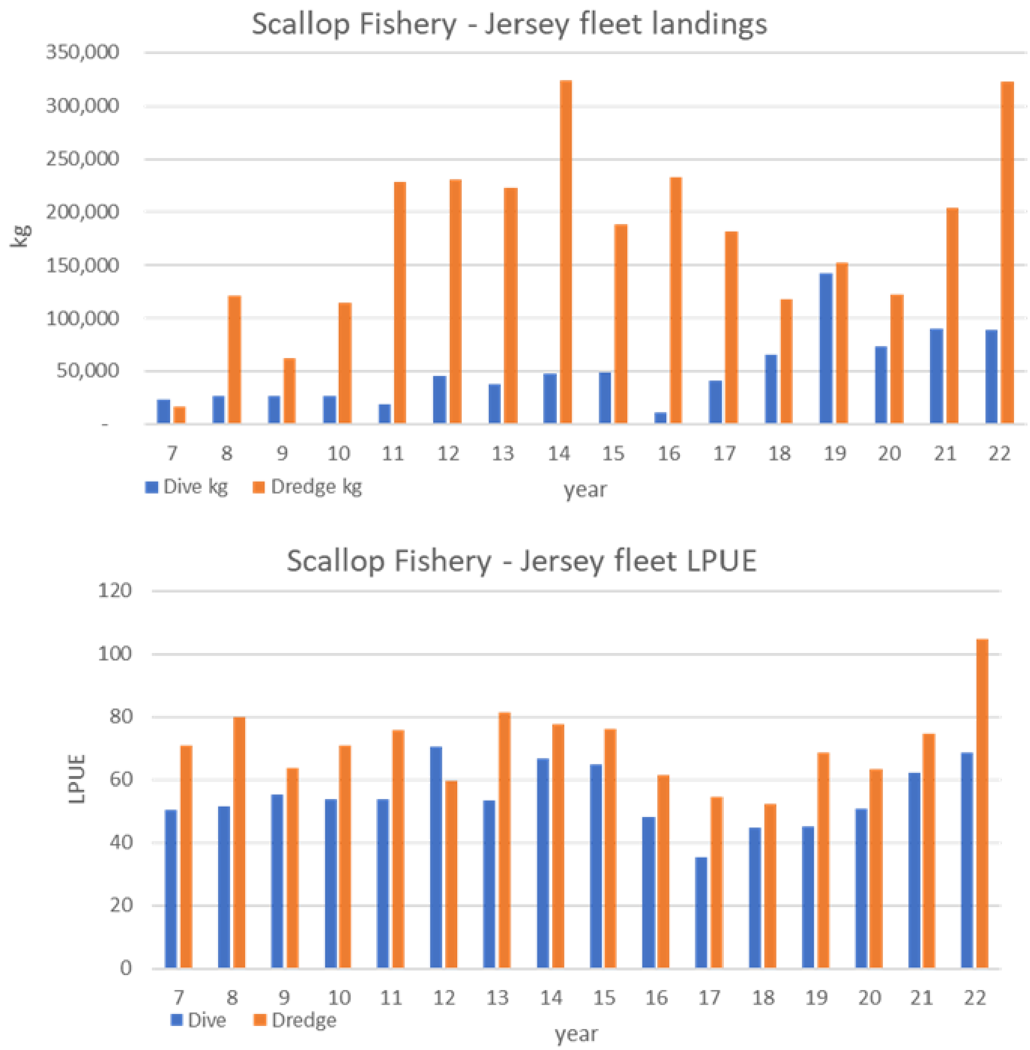


Figure 38. Landings (kg; top) and LPUE (bottom) for Jersey scallop fishing fleet from 2007–2022.

Jersey reported progress on installation of iVMS units on the full commercial fishing fleet with a plan for 15-minute ping rates dropping to 3-minute pings in close proximity to No Mobile Gear Zones.

France, Eastern Channel and Bay of Seine update: King scallop (*Pecten maximus*)

King scallop landings in the Eastern English Channel present a continuous increasing trend since 2000. From 7695 tonnes in 2000, landings were 36395 tonnes in 2022 (representing a fivefold increase) which is the highest level of catches ever reached (Figure 40). At the same time, fishing effort has fallen significantly, yields are much better today than 20 years ago. These landings were made by two main countries, France and UK (respectively 26602 tonnes and 9066 tonnes in 2022, corresponding to 73% and 25%). The remaining 2% are catches of Ireland (146 tonnes) and Belgium (213 tonnes).

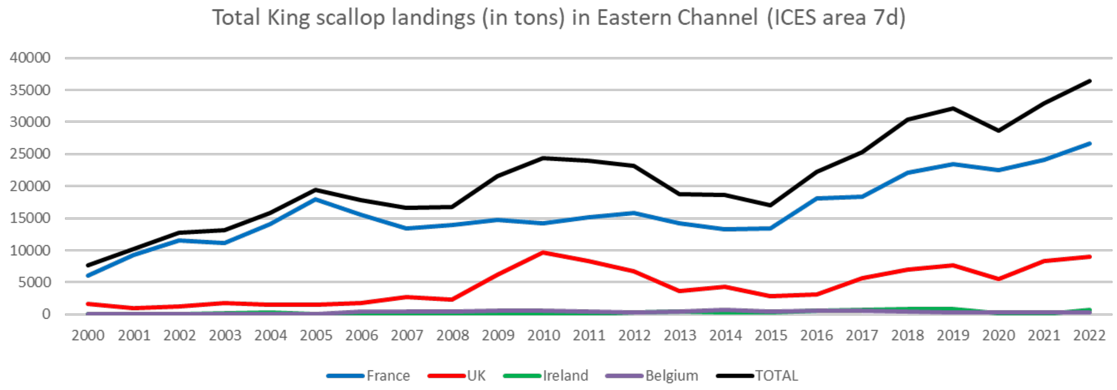


Figure 39. Trends 2000–2022 of King scallop landings in the Eastern English Channel.

In France, King Scallop fishing is a seasonal activity, as it is only 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 2022–2023 was the best ever observed since the origin of the fishery, which succeeded the 2021–2022 season, which was already the best in the time-series. 38800 tonnes were landed, an increase of 9% compared to the previous season 2020–2021 (which was already the best season ever recorded with 35800 tonnes landed). The Bay of Seine alone (statistical rectangles 27E9 and 28E9), could be considered as the heart of the King scallop seabed in Eastern Channel. Indeed, Nicolle *et al.* (2013, 2017[2]) shown that most of the larvae released in the Seine Bay will remain there according to the circulatory movement of the water masses, while the others will help to renew the stock in the eastern Channel. Today, the Bay of Seine represents 77% of the total French landings of Eastern Channel (20486 tonnes for the 2 ICES rectangles 27E9 and 28E9), but also 21% of UK landings (nothing in 27E9 all in French territorial waters, 1908 tonnes in 28E9).

Seasonality is very marked in the Bay of Seine (ICES rectangles 27E9 and 28E9), exploited almost exclusively by the French fleet. The most important months in terms of landings are November and especially December (before the end-of-year holidays). These landings have been steadily increasing in recent years, particularly since 2016 (Figure 41).

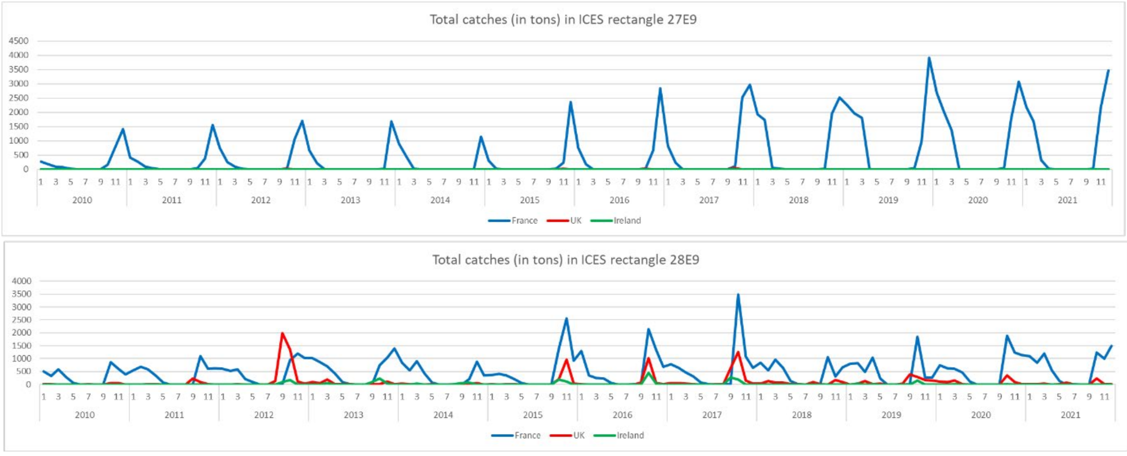


Figure 40. King scallop landings (2010–2021) in the bay of Seine (Eastern Channel, ICES rectangle 27E9 and 28E9).

The northern and central parts of the Eastern Channel, exploited more by British fleets, have a less marked seasonality. The 29F0 rectangle is exploited in a similar way by the two countries, but also to a lesser extent by the Irish fleet (Figure 42).

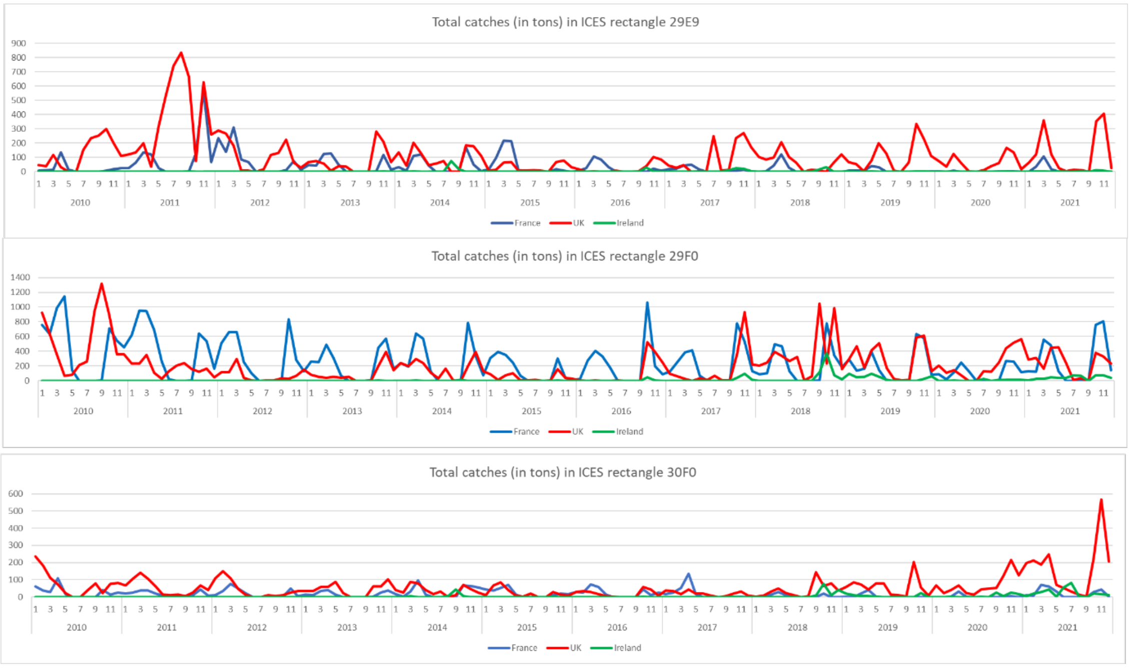
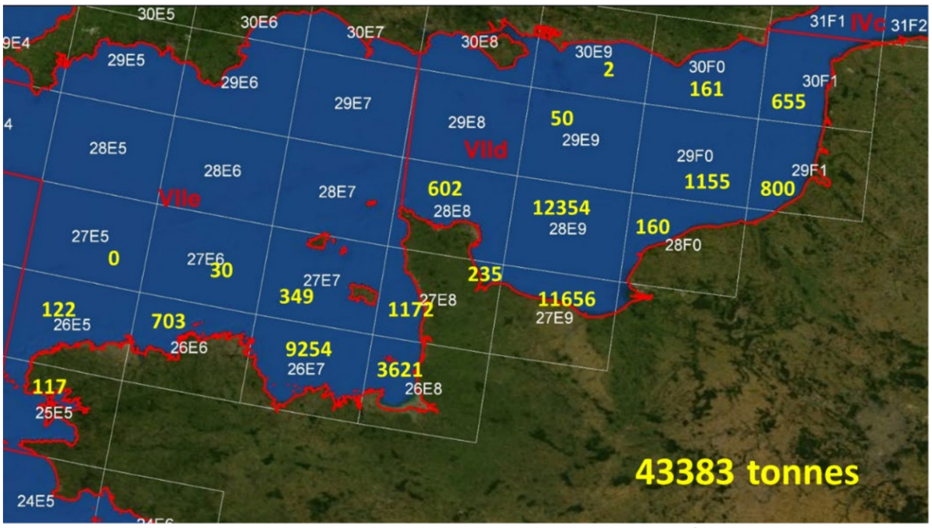


Figure 41. King scallop landings (2010–2021) in the northern and central parts of Eastern Channel.

For the whole English Channel (7d,e), the total French landings for the last fishing season 2022–2023 (from October 2022 to May 2023) reaches 43800 tonnes, up by 12% on previous year. Most of them come from the Bay of Saint-Brieuc (9254 tonnes in 26E7) and the Granville bay (3621 tonnes in 26E8) in Western Channel (Figure 43 and Figure 44).



Données SACROIS (DPMA/Ifremer SIH)

Figure 42. French King scallop catches for fishing season 2022–2023 in the English Channel.

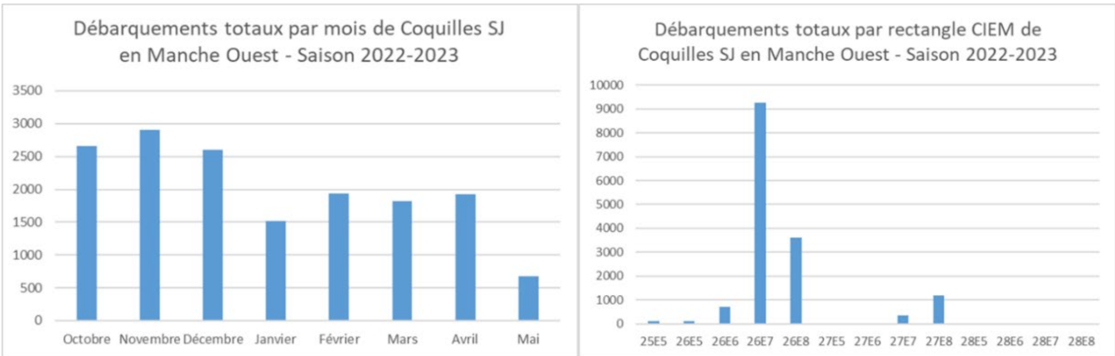


Figure 43. French landings for fishing season 2022–2023 in Western Channel, by month and ICES rectangles.

In the Eastern Channel (Figure 43 and Figure 45), most of French landings come from inshore waters in the bay of Seine (24010 tonnes in 27E9 and 28E9).

Bay of Seine stock assessment: results of COMOR2023 survey (July 2023)

Ifremer leads an annual stock assessment survey in this extended Bay of Seine area, located between the French coast in the south and parallel 49°48 in the north (Figure 46). 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 miles limit).

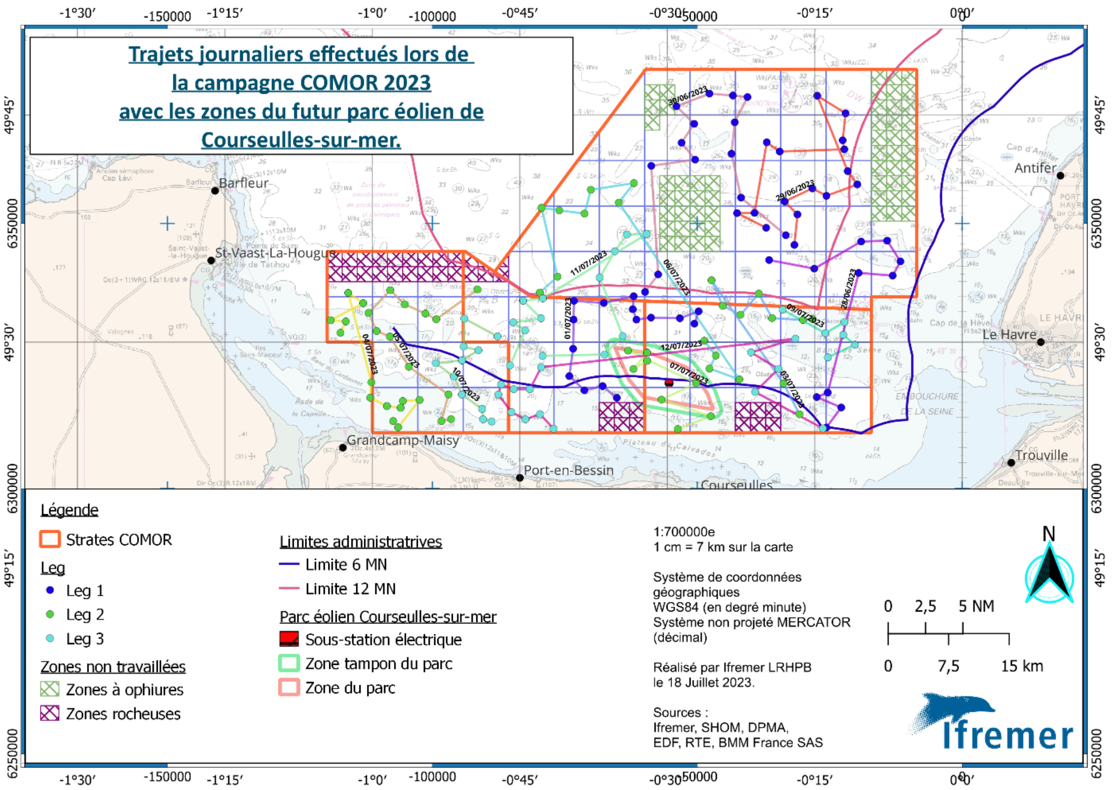


Figure 44. Scientific COMOR survey area (form Normandy coast in the South to 49°48 parallel in the North), and sampling units in 2023.

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

In the area "Extérieur baie de Seine", the 2023 abundance indices for 2-year-old scallops (recruitment) and those aged 3 years and over (age classes already exploited in previous fishing seasons) are slightly lower than in 2022. If this was expected for recruitment (the 2022 abundance index for juveniles being relatively low), there should probably have been more aged King scallops given the 2022 abundance. However, the overall abundance indexes remain good (5th best in the series). The abundance index for 1-year-olds (prerecruitment), on the other hand, is the highest ever observed and predicts a huge recruitment next year (Figure 47).

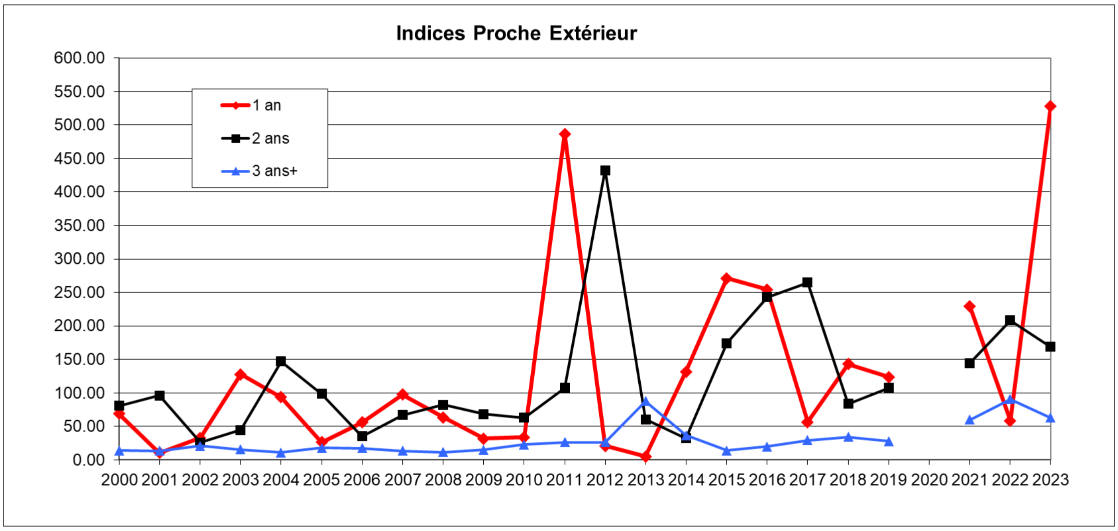


Figure 45. Trends of abundance indices by year class in the area "Extérieur Baie de Seine".

The exploitable biomass (when all individuals of age 2 and over have reached the minimum catch size of 11 cm) is thus estimated to be a little bit less compared with 2022 (Figure 48): 15418 tonnes compared with 20044 tonnes, -23%), but this value continues to be at a high level compared to the average 2000–2022.

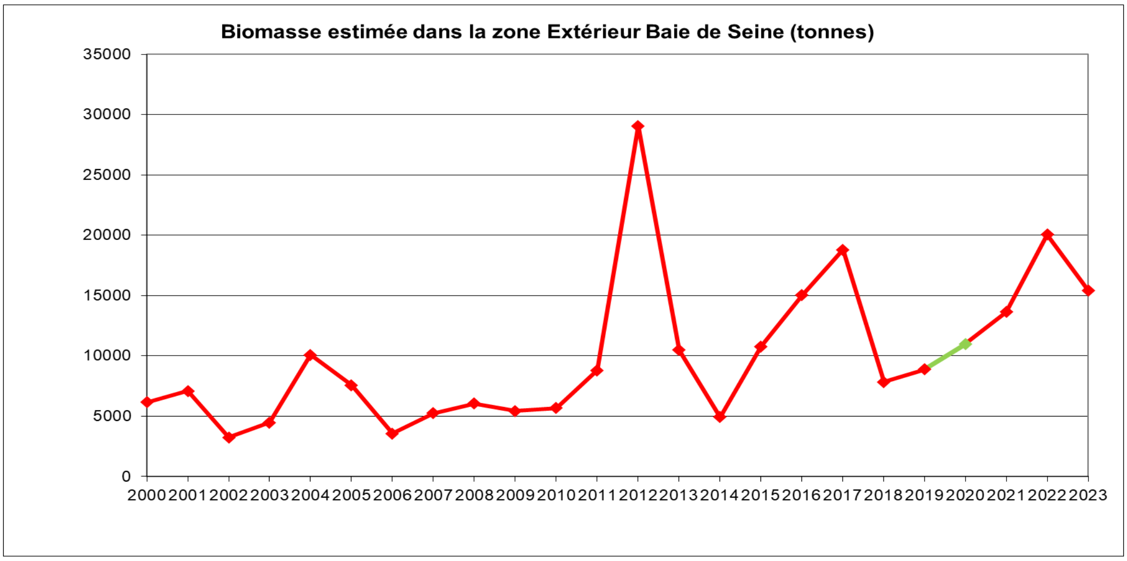


Figure 46. Trend of exploitable biomass in the area "Extérieur baie de Seine".

In the Bay of Seine, the abundance index of 2-year-old scallops continues to be very high, quite at the same level as the values for 2017, 2018 and 2021. This is the fifth highest value in the historical series. The abundance index for 3-year-olds and older is the second highest value of the time-series, although given the record abundance observed the previous year we were expecting to see the absolute record. The juvenile abundance index is the highest never observed since the beginning of the COMOR surveys, far surpassing the previous record set in 2016 (Figure 49).

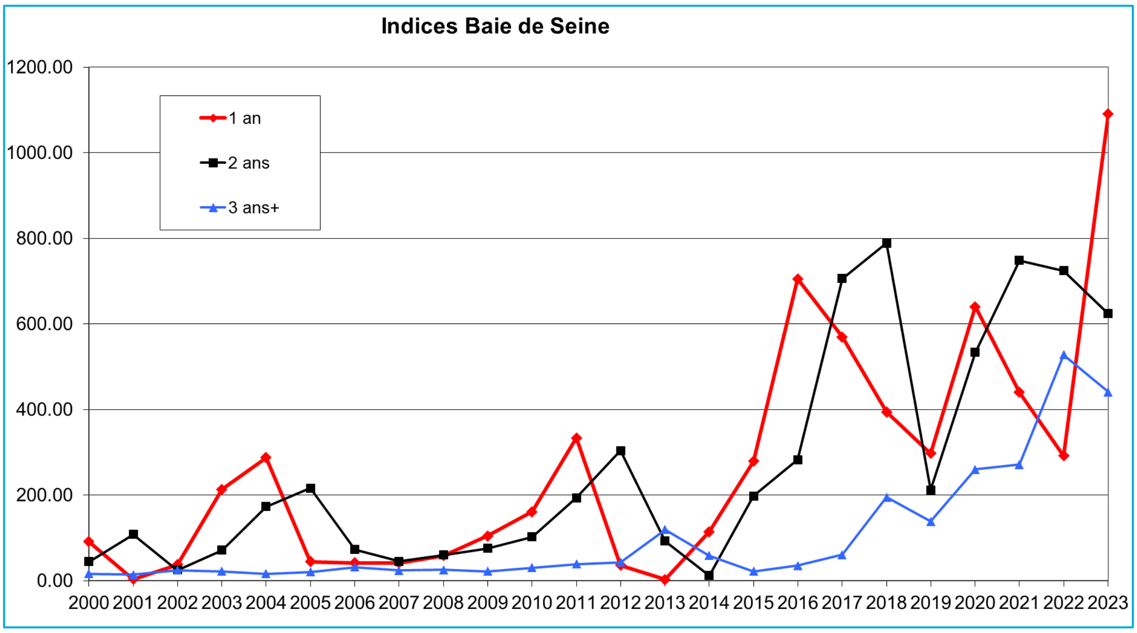


Figure 47. Trend of abundance indices by year class in the area "Baie de Seine".

As a result, the total exploitable biomass remains at very high levels, even if it does not surpass the record set in 2022 (Figure 50). The stock is considered to be in good ecological condition.

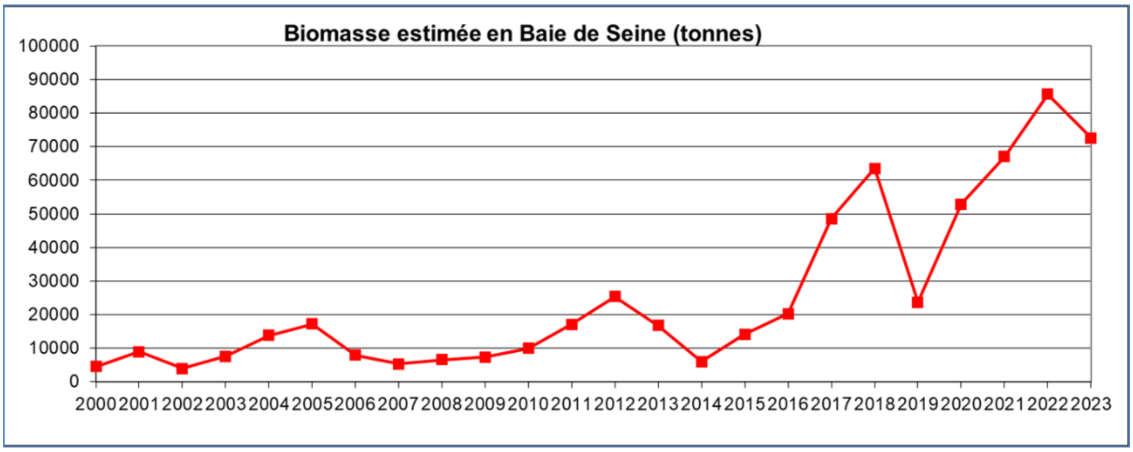


Figure 48. Trend of exploitable biomass in the Bay of Seine.

The population structure between the different age classes is well balanced (Figure 51), and makes it possible to envisage sustainable professional exploitation, provided that the environmental conditions remain favourable and that the fishing effort remains stabilised at the current level.

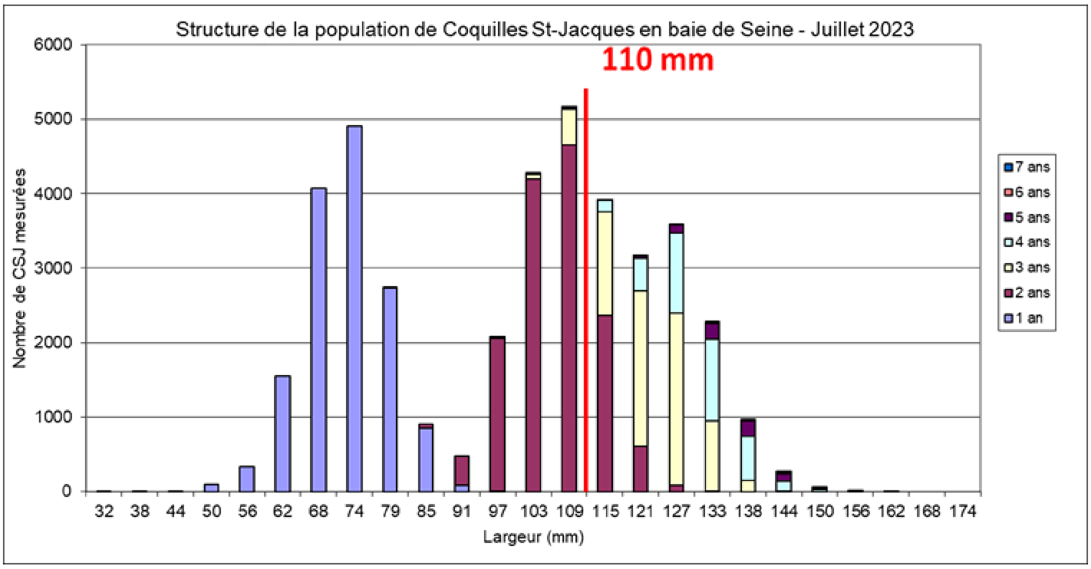


Figure 49. Population structure in the Bay of Seine.

With the exception of the oldest King scallops, and in contrast to previous years, the growth deficit that had been observed seems to be disappearing. The average size of 2-year-old scallops is identical with the average size for the period 1992–2022, and 1-year-old juveniles are much larger than this average (Figure 52).

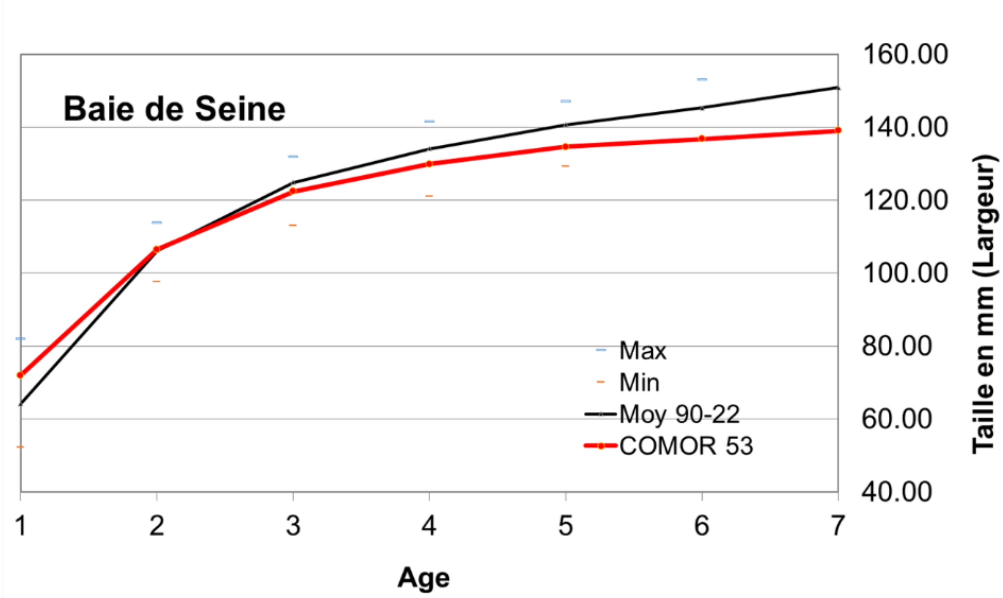


Figure 50. Growth curve observed in July 2023 for King scallop in the Bay of Seine.

Finally, the total exploitable biomass reaches in the two areas a total of 88032 tonnes, just below the previous record of 2022 (105,625 tonnes) (Figure 53).

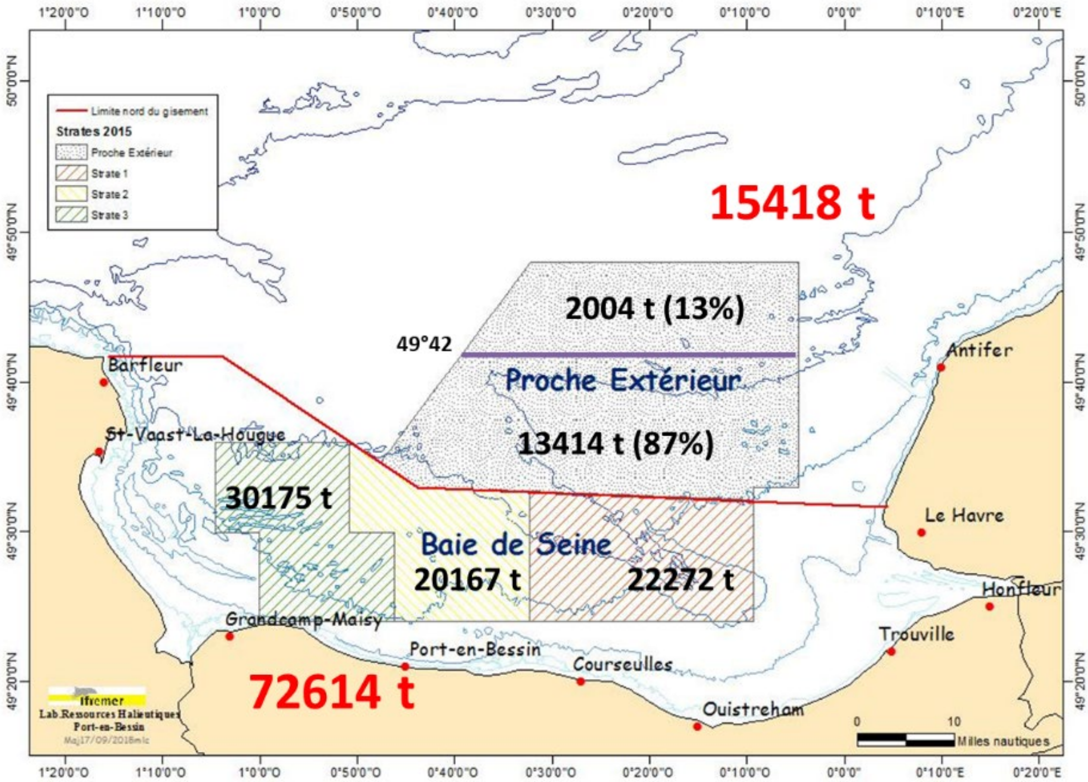


Figure 51. Exploitable biomass distribution per area in 2023.

The distribution on the seabed is relatively homogeneous in all areas of the Bay of Seine. On the other hand, yearling juveniles are a new time mainly found in the western part of the Bay of Seine (Figure 54). As the western area (area B1) was closed last year, as part of the rotational closure system put in place, the central western area B2 will be proposed this year for closure for the 2023–2024 fishing season.

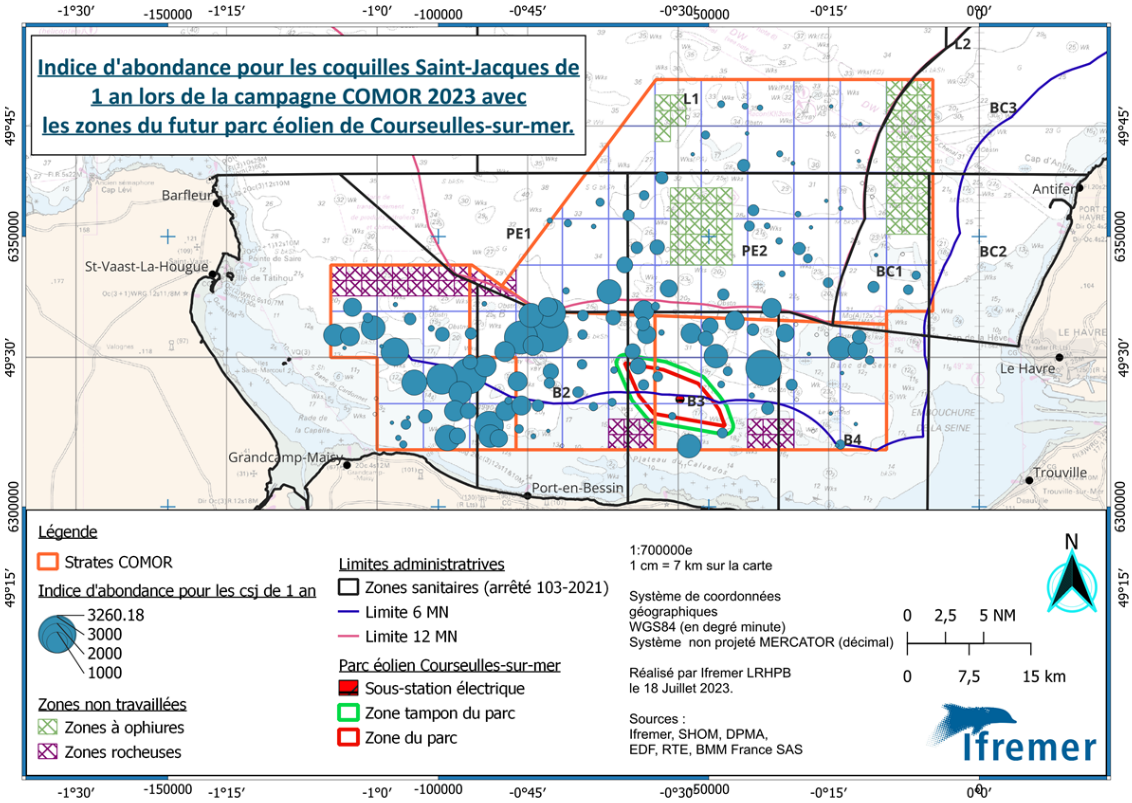


Figure 52. Geographical distribution of 1-year-old juveniles in 2023.

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

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 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. The spatial resolution of genome-wide markers was tested across three locations in the Firth of Clyde (UK) and two locations in the Irish Sea (Isle of Man and Cardigan Bay, UK), where patterns of genetic differentiations were expected based on previous study by Hold *et al*. (2021). Preliminary results using low-coverage (10x) whole-genome sequencing showed no clear genetic separation between Cardigan Bay, Isle of Man, and the Firth of Clyde. Instead, a potential stepping-stone scenario was found in a spatial gradient of ~ 400 km, where gene flow from Cardigan Bay and the Firth of Clyde is possibly maintained by intermediate scallop grounds. Although local genetic differences were expected, those results are overall congruent with previous studies that overall support the hypothesis of a generally panmictic population in British waters (Hold, 2012, Szostek, 2015; Morvezen *et al*., 2016; Vendrami *et al*., 2019; Handal *et al*., 2020).

More notable were two different genetic clusters that were unrelated to sampling locations. A possible explanation could be linked to seasonal spawning events in April-May and August-September (Comely, 1974; Duncan *et al.*, 2016) that can temporally isolate generations of early-spawners from late-spawners, creating two distinct genetic clusters. This is congruent with other studies that showed how genetic structure in broadcast-spawning organisms can be influenced by temporal variation in reproductive success and larval dispersal, highlighting local genetically different cohorts and temporal instability (Eldon *et al.*, 2016; Handal *et al*., 2020; Hold *et al*., 2021). To test this hypothesis, $\delta^{18}O$ values of four shells from the Firth of Clyde (two shells for each cluster) were analysed to test if different scallops have been settled in spring vs. late summer. Previous studies have already demonstrated how *P. maximus* precipitate calcite in isotopic equilibrium with seawater, allowing $\delta^{18}O$ signatures to accurately track seasonal variations in bottom water temperature within ± 0.5°C (Chauvad *et al*., 2005; Freitas *et al*., 2012) and therefore track in time when individuals settled onto the seabed and commenced shell growth. Preliminary results indicated that shells from different genetic clusters appeared to have different temporal growth patterns. However, due to the small sampling size (2 shells from each genetic cluster) further analysis is needed to confirm those observations.

The WG was also presented with an update from another PhD student who has been working on mathematical modelling of P. maximus in Scotland. The student is based at the University of Strathclyde, and their project is funded by the Natural Environment Research Council. At last year's Scallop Working Group meeting, the student reported spending summer months on a research exchange in Halifax (Nova Scotia, Canada), where they investigated options for particle trackers to be used for simulation of scallop larvae motion. Over the last year the PhD student and their research team at Strathclyde decided to move to a different tracker, named FISCM. This collective decision was reached after considering availability of local technical support, as well as using a tracker which has been recently edited to be used with forcing fields derived from the Scottish Shelf Model. FISCM was first suggested as an option to the student by their CASE partner Marine Scotland and is also being used by another student based at the Department of Mathematics and Statistics at the University of Strathclyde who is working on salmon.

To perform simulations, the student derived maps for particle release zones (Figure 55). These were created by combining declared end and start locations of scallop surveys during the years 2010–2019, from datasets provided by Marine Scotland, and publicly available VMS data covering the period from 2009 to 2013 (https://data.marine.gov.scot/dataset/2009-2013-amalgamated-vms-intensity-layers/resource/6cd5af24-e15b-4d1c-91a4-c8359d898434). R software was used to generate polygons from the VMS data, and this was subsequently combined with the survey locations by using a combination of buffers around the points and generating convex hulls. The student identified 12 release zones in Scotland.

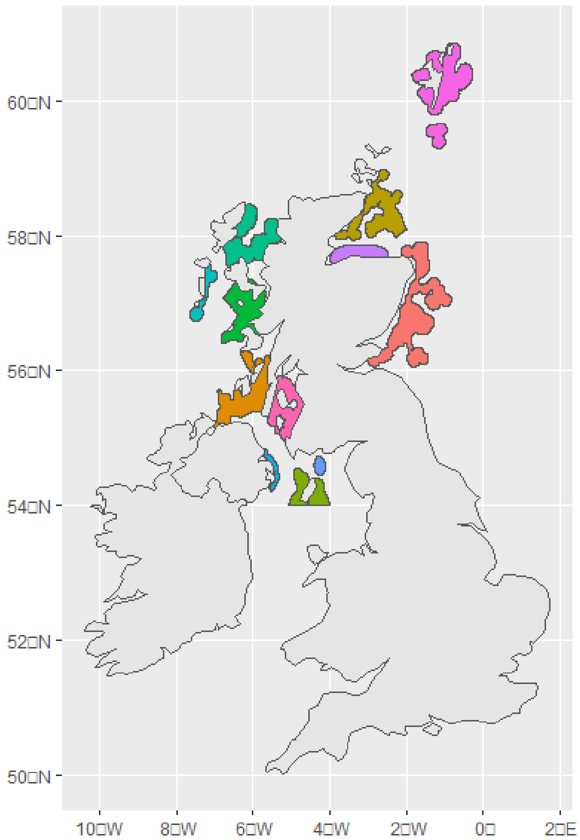


Figure 53. A map showing the 12 release zones in Scotland.

Additionally, a literature review of scallop spawning behaviour and analysis of gonad data provided to the student by Marine Scotland identified highly variable trends in spawning activity. Scallops display complex spawning behaviours, with some individuals only emptying their gonads partially (Mason, 1958). Notably, some populations spawn asynchronously, while others display greater synchronicity (see for example Paulet *et al*., 1988). The timing of the spawning is influenced by many factors, including sea temperature and sunlight. As there is potential for great variability in scallop behaviour in the area covered by this PhD project, the student decided to run simulations with three plausible scallop spawning behaviours:

- Scallops spawning all at once in late spring (May), and then again later in summer (July/August).
- Scallops spawning all at once only in summer (July/August).

- Staggered spawning in May, and then again in July/August.

Preliminary runs highlighted some issues with the tracker, and the student has been working in collaboration with their supervisors and an academic contact in Canada to run diagnostic tests and a sensitivity analysis to tune parameters used in the tracker. The next step will be producing simulation outputs with the intent to create transport matrices for larvae between the 12 zones identified and assess connectivity.

The student has also been working on developing a dynamic model to simulate the growth and maturation of an individual scallop under environmental forcing such as temperature and food availability. This model will then be combined with the particle tracker to simulate spawning events based on local environmental conditions.

The WG was also updated on a Northern Irish larval dispersal modelling project named MerMADE. MerMADE is a coupled biophysical, eco-evolutionary modelling software for predicting population dynamics, movement and dispersal evolution in aquatic environments. It is spatially explicit, individual based and incorporates external forces like hydrodynamics with biological, physiological processes like growth, development, dispersal. It bookends the pelagic dispersal phase of focal species with population dynamics and evolutionary capabilities over long periods of time. It includes functionality such as implementing patch-extinction scenarios, harvest pressure and habitat fragmentation.

MerMADE used the sandeel (*Ammodytes spp)* fishery in the North Sea as a case study. It is a major commercial fishery, an important food source for seabirds, marine mammals and other commercially important fish species. The fishery is managed as six demographically distinct areas within the North Sea, which are treated as closed, well-mixed systems meaning that where you fish shouldn't matter because movement within the assessment area is assumed. Concerns over sandbank patch depletion due to high levels of harvest pressure have been a topic of conversation for some time, so patch-depletion scenarios were run to assess the impact of these on the connectivity and overall population stability of the assessment area. The model was used to calculate connectivity metrics including origin and destination centrality, which is how many other patches are fed by and feeding the focal patch, respectively. This gives an idea of spatial patterns of connectivity across the map and isolation of patches. From this, a selection of patches were chosen to deplete and the effect on the rest of the system was observed. For more details see Allgayer *et al.,* 2022.

MerMADE was applied to the *P. maximus* fishery in Northern Ireland to identify areas for seeding that would bolster the population and help the fishery recover from very low densities. Four areas have been closed by the fishery and are being considered for enhancement so we released individuals from those four sites: Whitehead, Drumfad Bay, Ballyquintin, and Roaring rock. Species-specific dispersal and population dynamics parameters were included as best we could and simulations run for spring as well as autumn spawn. Whitehead and Drumfad Bay had a circular movement pattern and stayed within the study site but settled on the west coast of Scotland instead of the Northern Irish coast, though in autumn spawn there were more eddy patterns that may lead to retention in some cases. Roaring Rock and Ballyquintin had the strongest seasonal differences in movement tracks. From Roaring rock, individuals were all transported south and out of the study area in April while they were transported east and out in September. From Ballyquintin, the April dispersers got stuck on the southern edge of the map, we theorised that they hit the gyre present there, and were likewise transported east and out of the area in September. Overall, the two northern sites are more promising for enhancement.

The future plan is to develop MerMADE to be able to do hindcasting to see where the population that has settled in the Northern Irish fishery have come from.

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

A presentation was given by Ava Ocean (from onboard their research vessel). Ava Ocean is an ocean technology and seafood company pioneering new ways of harvesting the abundant seafood resources on the seabed, in a gentle, yet effective manner. Ava Ocean has developed a revolutionary technology for non-invasive, precision seabed harvesting that not only preserves, but can also help to restore fragile and often overlooked ecosystems on the bottom of the sea.

The company's first fishing vessel, the Arctic Pearl, is the world's first with this technology onboard. Thanks to the harvesters' documented low impact, in December 2022 the Arctic Pearl was able to reopen the fishery of Arctic scallops in the Barents Sea after 30 years of closure. Ava Ocean, previously operating under the name of TAU Tech, was established in 2016 and is based in Aalesund, Norway. For more information, visit us on www.avaocean.no or LinkedIn.

Update on Low Impact Scallop Innovation Gear (LISIG) project

The scallop sector is one of the highest value commercial fisheries in the UK and supports a highly productive catch sector and processor businesses. Yet, management of the UK scallop fisheries lagged other fisheries in the UK and at present the UK scallop fishery would not meet the sustainability standards such as those set out by the Marine Stewardship Council (MSC). Efforts are being made by the fishery to move towards a more sustainable fishing practice and towards net zero. Technical gear modifications are one of several management measures and industry actions that can be taken to reduce impacts on target stocks and the environment, while maintaining an acceptable level of commercial viability for the fishery.

The LISIG project is an industry-science collaboration project working towards an economically viable gear innovation that aims to reduce environmental impacts associated with spring-toothed Newhaven dredge (aka standard dredge) that is commonly used by the UK scallop fishery to catch king scallops (*Pecten maximus*). The proposed modification involves adding 'skids' to the bottom of the belly bag to lift the belly bag off the ground and thus reduce the contact and drag of the belly bag with the seabed. Data on the retained catch and bycatch, catch selectivity and damage, seabed fauna damage, fuel consumption and gear wear were collected during scientific field trials and commercial practice with fishermen in 2021–2022 to assess the environmental impact and commercial viability of the modified skid dredge relative to the standard dredge.

The modified skid dredge generally caught more marketable scallops per unit area fished compared with the standard dredge (+5%). However, the skid dredge also retained more bycatch (+11%) and more undersize scallops (+16%). The performance of the two dredges was habitat specific which indicates the importance of adjusting management measures in relation to habitat type. To realize the potential environmental benefits associated with the improvement in catchability of this gear modification, further gear modification is required to reduce the catch of undersize scallops and bycatch. Furthermore, we advocate that technical gear innovations in scallop dredging need to be part of a comprehensive and effective fisheries management system.

Full scientific report available here and two minute video available here.

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 Workshop on Scallop Aging was established as part of this ToR to provide a platform to enhance information flow and progress shell aging processes across diverse fisheries, stocks and populations, vital for use in fisheries stock assessments and informing any future ecosystem-based fisheries management (see Workshop on Scallop Aging 2 (WKSA2) report).

The first workshop was held in Marine Scotland and was attended by 22 participants from 8 institutes. Good progress was made; however, it was requested to have a second workshop (WKSA2) to focus on microscope age training, consensus to improve accuracy and agreement and undertake further SmartDots work. See https://www.ices.dk/data/tools/Pages/smartdots.aspx for an introduction of the ICES SmartDots biological reading platform. Due to the coronavirus pandemic, the second WKSA2 workshop was split into two parts: a virtual online meeting (October 21) and a hybrid event (March 23) which was held at Cefas, Lowestoft, UK.

The virtual WKSA2 meeting discussed methodologies, quality assurance aims and a further Smartdots event. The hybrid workshop comprised of a two-day in-person microscope age determination training workshop and the release of a second Smartdots event. The meeting was attended by 14 participants in-person, 5 online, with 9 country institutes represented. During the workshop, the participant institutes shared techniques to help develop age determination processes and consensus, discussed agreed standard principles for exchanges and promoted knowledge sharing. SmartDots was trialled further to examine its potential use for virtual scallop shell aging in future exchanges.

Terms of Reference ToR's for ICES Workshop on Scallop Aging 2021/22:

a) Create, collate and consensus age a reference collection of scallop shells for the participating institutes across geographical fishery locations.
b) Carry out microscope aging QC consensus training.
c) Further progress the use of SmartDots technology for virtual aging King scallops
d) Agree quality assurance parameters for scallop aging.
e) Review new and evolving methodologies in scallop age techniques.
f) Maintain a regular platform to progress information flow and develop consistent shell aging
g) Discuss the potential of applying similar age determination techniques to other scallop species in particular *Aequipecten opercularis*

An update of the WKSA2 inhouse microscope training workshop was given. Participants were trained in microscope age determination techniques for shells across various stocks. Resilia (located in the hinge of the shell) aging and hyperspectral images were discussed. A new SmartDots event ran alongside and post the WKSA2 workshop.

Full details of the workshop can be found in the ICES WKSA/WKSAII. The executive summary and recommendations are described below.

The WKSA2 group have made a series of recommendation to WGScallop for age determination in Scallops including:

a) Progress TOR a (3.1) ‘consensus age a reference collection of scallop shells’ with local ‘partner-institutes’
b) The initiation of a draft document for scallop aging methodologies to record current methodologies used by each institute.
c) WGScallop stock assessors to identify and advise the acceptable percentage concordance rate needed in age reading for an age-based stock assessment. This will feed into QC parameters for scallop aging and training.
d) Future WKSA meetings to continue biennially, alternating between virtual and in-person meetings. Virtual meetings can be focused on method and QC development and in-person meetings on consensus aging and methods training.

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

The most recent focus has been on the 'Identify, list and collate data' element of the ToR, building upon the work done by the subgroup in 2021. Revising the inventory was discussed, with contributions from all WG members requested. Incorporating survey data into the ICES data call was proposed in order to contribute to possible assessments. The group concluded we would postpone this due to not quite being ready across the board. Reinstating the subgroup meetings was discussed as well as a request for a co-champion to lead the ToR. Landings and effort data were collated (Table 9; Figure 57) but note that data for the Isle of Man are not available before 2011 and data for Scotland not available prior to 2002.

Table 8. 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
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

	ICES Subarea				
Year	IV	VI	VII	VIII	Total
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
2022	6.3	1019.3	7949.3	69.4	9044.3

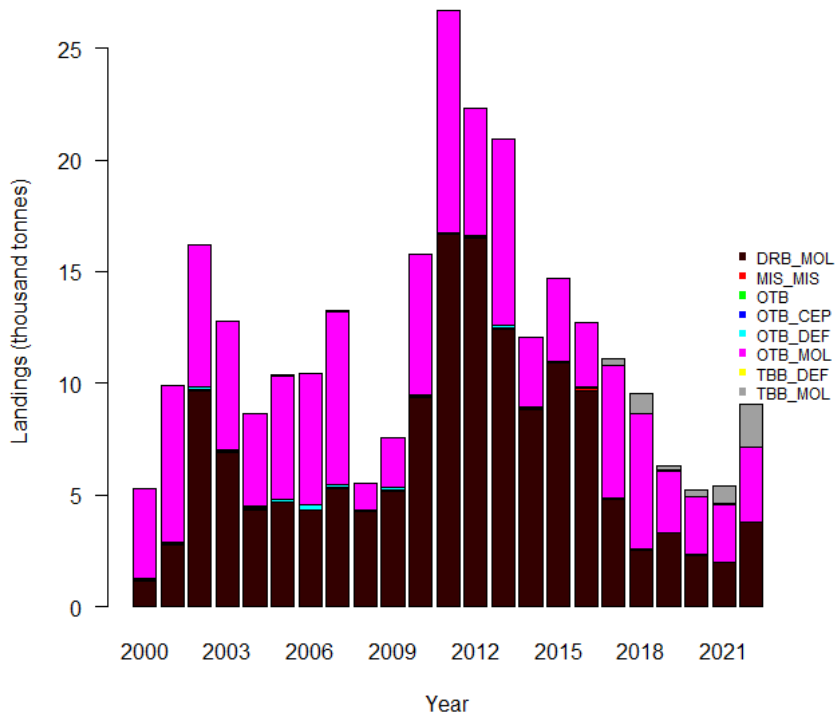


Figure 54. Annual landings (live weight (including shell), thousand tonnes) reported for queen scallops. Landings are divided by metier within each year as coloured by the legend. Data for Isle of Man are not included prior to 2011 and Scotland are not included prior to 2002.

At the working group meeting in 2020 a collaborative project to collect queen scallop samples from within ICES areas to explore methods and analysis for age and growth studies was agreed. Since then, samples have been collected and dissected from Isle of Man (Bangor University), Wales (Bangor University), Northern Ireland (AFBI) and England (CEFAS). The left valves of the dissected shells have been prepared for visual analysis and the external rings counted (Figure 58; left). Alternative methods are also being explored to validate this method and to enable accurate ageing when the external growth rings are less visible on the shells. As part of the WKSA II workshop in March 2023, the resilia of queen scallop shells were dissected and photographed and compared with external growth rings. These two ageing methods have good agreement in the small numbers of samples examined. The growth signatures on the resilia are difficult to extract intact if the shells have not been prepared prior to freezing for storage. As such, alternative methods for resilia preparation and extraction are currently being explored (Figure 58; right).

Figure 55. Left, left valve of a queen scallop shell prepared for external growth ring assessment. Right, resilia from a queen scallop shell (extracted prior to freezing/storage) and photographed under a microscope.

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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	8-10 October	TBD, France	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 and identify stock assessment methods for scallop species. Consider available data (at stock level) for stock assessment input indices and/or for review of stock trends.	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	Review and report on current scallop surveys and share expertise, knowledge and technical advances.	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.
d	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.
e	Review current biological parameters and any gear modification, technological advances, including electronic monitoring (EM) for scallop fisheries.	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.
f	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.
g	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 grouj 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: WGScallop Data

Table 9. Landings of king scallops (live weight, tonnes) by ICES statistical rectangle and year within ICES subarea VIIa (Irish Sea). 2022 data are provisional.

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	1.5*	162.7	5.3	3.8	56.4	13.4	0.5
2022	0	4.8	4.4	1447.7	8.9	0.4	188.9	2.1	3.7	53.2	65	10.1

*Amendment made to submitted data (from 1.4 to 1.5)

Table 10 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
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
2022	37.8	746.2	556.8	0	1.8	104.4	1356.5	10.2	0.2	199	140.2	0.8

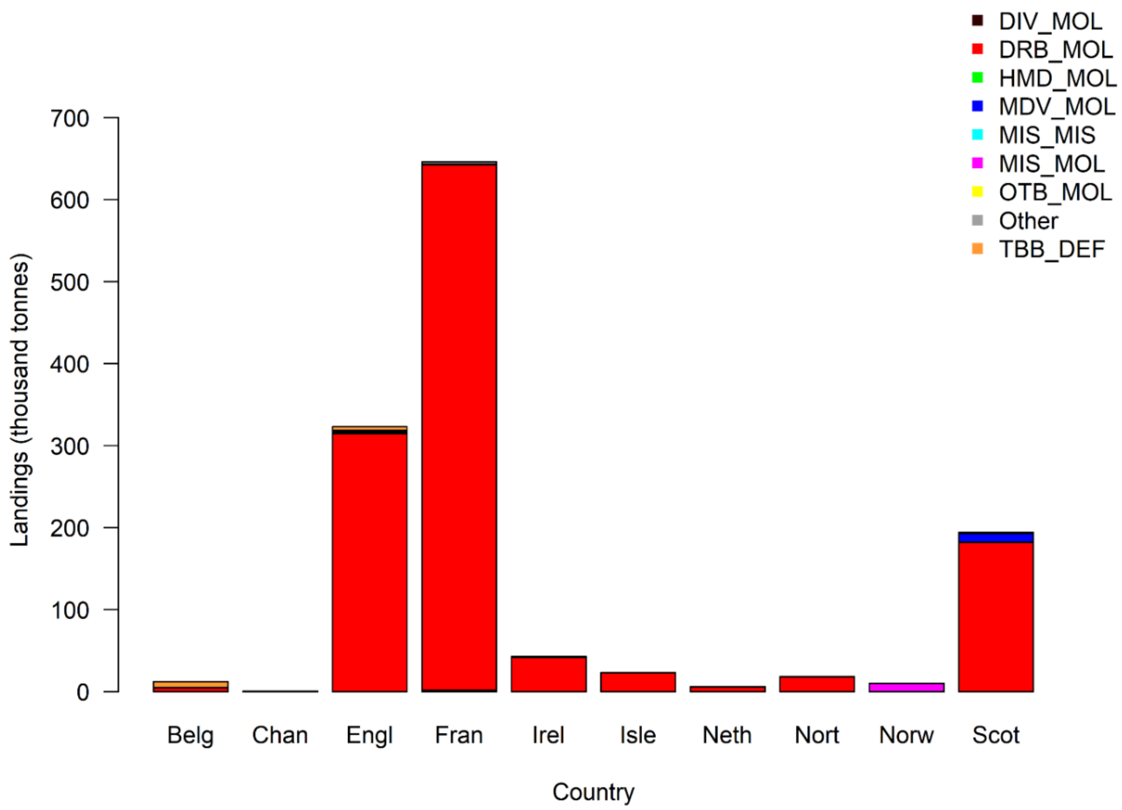

Figure 56. Landings of king scallops (live weight, thousand tonnes) in the data call by country and métier. Métier classified to Level 5. The eight métiers with the highest landings are shown, with all others classified in to 'Other'. Begl is Belgium, Engl is England and Wales, Fran is France, Irel is 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.

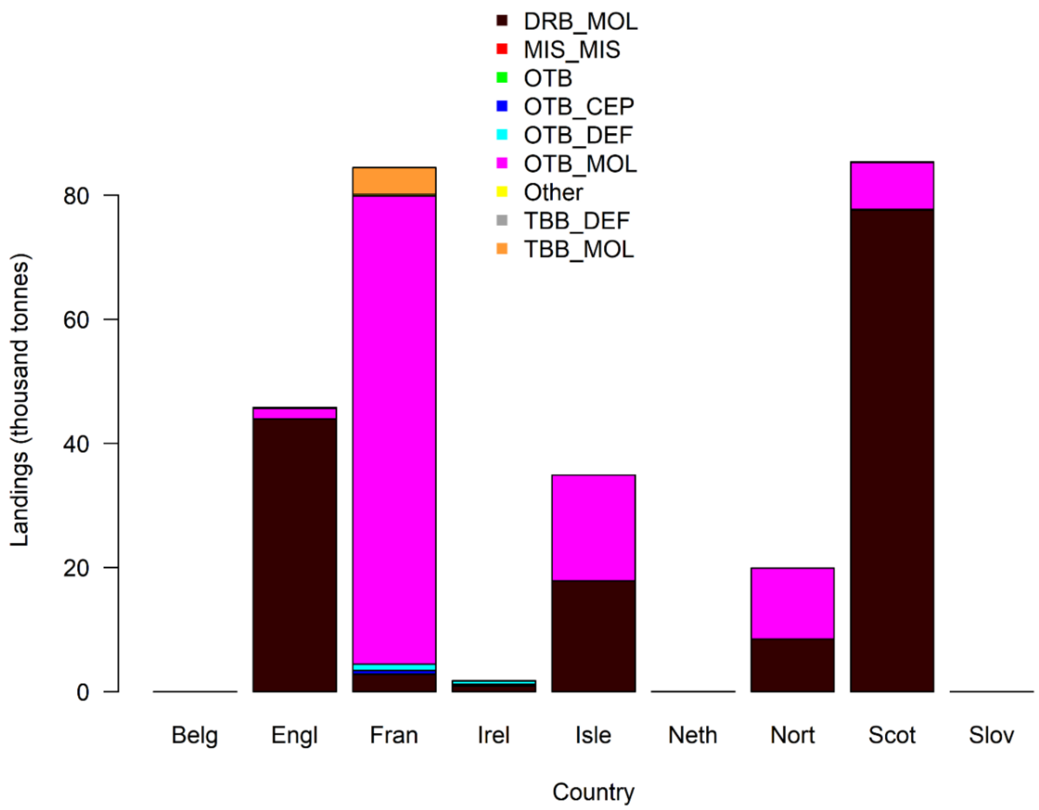

Figure 57. Total landings of queen scallops (live weight, thousand t) in the data call (2000-2022) by country and métier. Métier classified to Level 5. The eight métiers with the highest landings are shown, with all others classified in to 'Other'. Engl is England and Wales, Fran is France, Irel is the 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.

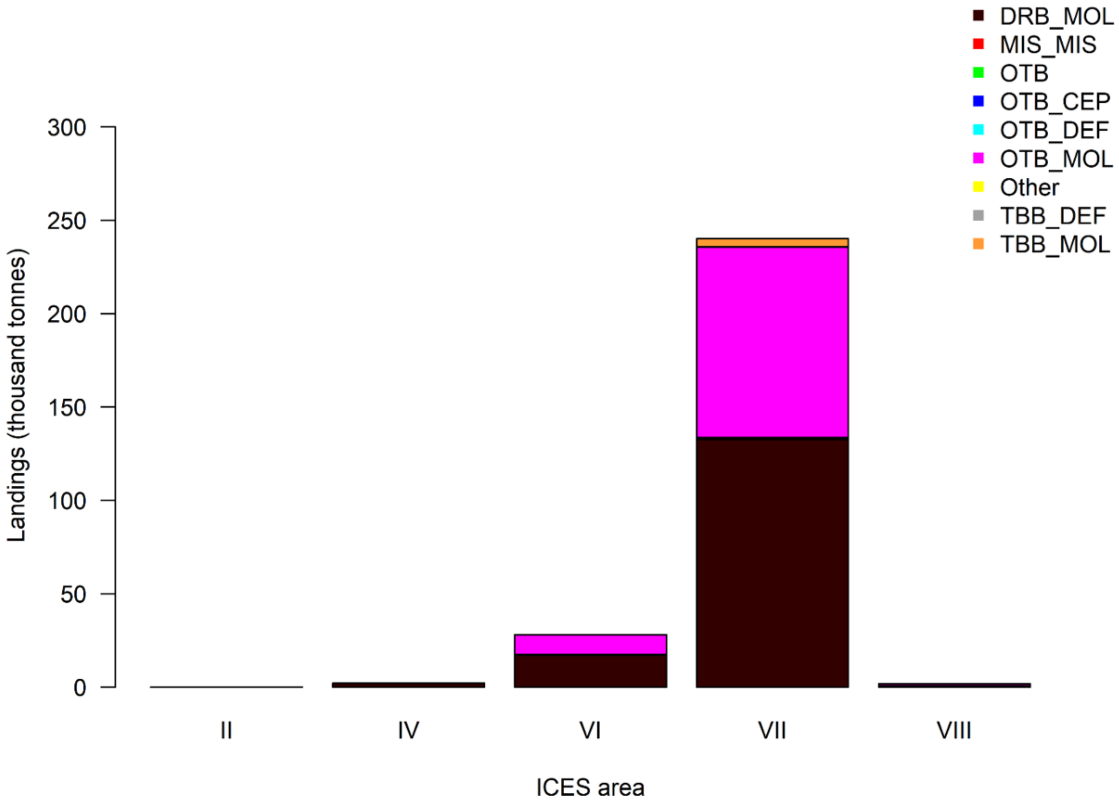

Figure 58. Total landings of queen scallops (live weight, thousand tonnes) in the data call (2000–2022) by ICES area and métier. Métier classified to Level 5. The eight métiers with the highest landings are shown, with all others classified in to 'Other'. DRB_MOL is dredges targeting molluscs, MIS_MIS 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.