ICES WGSCALLOP REPORT 2016

ICES ADVISORY COMMITTEE

ICES CM 2016/ ACOM:24

REF. ACOM

Report of the ICES Scallop Assessment Working Group (WGScallop)

3-7 October 2016

Aberdeen, UK

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

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Conseil International pour l'Exploration de la Mer

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Contents

1 Executive summary

The working group has assembled information on the location of fishing effort, methods of surveying, population dynamics, biological parameters, fishery reference points and habitat impacts for the King, Queen and Icelandic scallops in ICES areas: 2a, 4a, 4b, 5, 6a, 7a, 7d, 7e/h, 7g, and 8, as outlined by the ToR's, as they stand now based on the research of individual groups and organizations. However, for many stocks this information is incomplete.

The fourth meeting of the ICES scallop working group in Aberdeen, Scotland was highly productive, consisting of summary presentations addressing the terms of reference. We are moving towards an understanding of the status of the stocks within the ICES areas. The data presented suggest that several stocks are doing well, with indices either holding steady or increasing from the previous 3 years, while a few seem to be in decline such as the Celtic stock.

There has been a large King scallop recruitment in the Baie des Seine suggesting extremely good landings in the upcoming year, however, this also reflects the need for a global plan as fleets from a number of different countries are fishing together in a small area (>60 vessels). This seems to be resulting in "the tragedy of the commons" scenario, making sustainable management decisions difficult.

The workshop began with review of the ToRs. Discussions focused on: 1) stock structure: if there was new evidence and sufficient information to draw boundary lines; 2) Surveys, most countries are conducting surveys, England is developing one for the channel, Ireland is not doing surveys; 3) Ageing: there is a need to standardize aging techniques for use in stock assessment models. For example, there are large differences in age structure across King scallop stocks; in the Baie des Seine scallops reach harvestable size at 2 years of age, and the population is dominated by scallops < 5 years of age. In contrast, in some areas around Scotland there are a large proportion of scallops aged 10+. Is this completely an environmental/biological difference or do different aging techniques influence these results?) Seabed impacts: several presentations examined aspects of this, including bycatch, discard mortality and VMS data.

Moving forward we propose to compile landings and effort (kilowatt days, VMS hours) data by ICES rectangle or on finer scale to aid the process of defining stocks, conduct an ageing methods intercalibration exercise through a shell exchange, examine connectivity between stocks, and continue to examine biological variables including habitat impact.

The growing need for global assessment of scallops is becoming increasing apparent and the group plans to use the Baie Des Seines/English Channel and the Irish Sea/Isle of Man fisheries as case studies to explore this.

2 Administrative details

Working Group name

WGScallop – Working Group on the Assessment of Scallop fisheries

Year of Appointment within the current cycle

1st year within second 3-year cycle

Reporting year within the current cycle (1, 2 or 3)

Year 1

Chair(s)

Kevin Stokesbury, USA

Meeting venue

Aberdeen, Scotland

Meeting dates

3–7 October 2016 (16 participants)

3 Terms of Reference

2016/2/ACOM24 The **Scallop Assessment Working Group (WGScallop)**, chaired by Kevin Stokesbury, USA, will meet in Aberdeen 3–7 October 2016, to

WGScallop TORs 2016-2018

1) Compile and present data on landings and fishing effort that allows the following data products to be produced at as high a spatial resolution as the available data allows in ICES areas 4, 6 and 7. Refer to WGScallop 2015 for methodologies
   a) maps of fishing pressure, fishing effort and landings
   b) GLM/GAM standardised LPUE indicators of stock status
   c) maps of relative abundance of scallop
   d) best estimates of absolute abundance using available habitat specific gear efficiency estimates
   e) estimates of area of stock distribution exposed to fishing each year
2) Identify studies of larval source sink patterns to
   a) evaluate the potential value of protected areas as sources of scallop recruitment
   b) Identify populations that are important sources of larval supply
3) A) Review of current research underway on scallops, focusing on population dynamics, stock structure, life history and habitat impact of fisheries.

   B) Compare basic models derived from landings and effort to more complex models where they are available. (link to WKLife)
4) Estimate scallop discard mortality

WGScallop will report by 2nd November 2016 for the attention of ACOM.

Supporting Information

PRIORITY:	ESSENTIAL
Scientific justification:	The proposal to initiate a WG on scallops is justified on the basis of the national and international importance of this fishery in a number of countries in northwest Europe and North America. There is currently no common scientific or assessment forum for discussion and development of common assessment methods for scallops. The qualitative descriptors for determining good environmental status (Directive 2008 EU) we are concentrating on are: **Descriptor 1:** Biological diversity is maintained. The quality and occurrence of habitats and the distribution and abundance of species are in line with prevailing physiographic, geographic and climatic conditions. **Descriptor 3:** Populations of all commercially exploited fish and shellfish are within safe biological limits, exhibiting a population age and size distribution that is indicative of a healthy stock. **Descriptor 6:** Seabed integrity is at a level that ensures that the structure and functions of the ecosystems are safeguarded and benthic ecosystems, in particular, are not adversely affected. The focus of the working group is to providing scientific advice on scallops, defining a common approach to the assessment of stocks. In the 2013 meeting the workshop examined ICES areas: 2a, 4a, 4b, 5, 6a, 7a, 7d, 7e/h, 7g, and 8. Scallop species and biological stocks were identified in each of the ICES areas.

4 Summary of Work plan

To complete compilation of landings, effort, fishing distribution data and to derive basic indicators of stock status. Evaluate how stock assessment methods proposed by WKLife can be applied to scallop stocks. Evaluate the potential benefit of MPAs and European marine sites as sources of scallop recruitment. Evaluate and report on bycatch species composition and also on discard mortality rates of undersize scallops with reference to the EU landings obligation.

5 List of Outcomes and Achievements of the WG in this delivery period

Stokesbury, K.D.E. Overview of ICES scallop working group 2013 to 2016. Southwestern Fish Producer Organization Ltd, Brixham, England. 11 Oct 2016.

6 Progress report on ToRs and work plan

The fourth meeting of the ICES scallop working group in Aberdeen, Scotland consisted of summary presentations addressing all the terms of reference. Each group compiled a summary paragraph of each presentation which are included in Annex 3 of this report. We are moving towards an understanding of the status of the stocks within the ICES areas. The data presented suggest that most stocks are in good shape, with indices either holding steady or increasing from the previous 3 years. There has been a large King scallop recruitment in the Baie des Seine, suggesting extremely good landings in the upcoming year, however, this also reflects the need for a global plan as fleets from a number of different countries are fishing together in a small area (>60 vessels) creating a "tragedy of the commons" scenario. Some of the Scottish King scallop stocks have lower recruitment in recent years. The Queen scallop's stock seems to be similar to last year for the Isle of Man fishery. This level is much lower than several years ago but in line with the historic mean, the previous high abundance may have been associated with a large recruitment class (an extreme recruitment event) similar to those occurring in the US sea scallop fishery. The Queen scallop stock around the Faroes Islands also seems to be strong. The Icelandic scallop stock has been closed since the population crash 20 years ago. Now there are strong signs that the stock is improving in some areas and exploratory fisheries are underway as are video quadrat surveys.

The workshop began with review of the ToR. Discussions focused around: 1) stock structure: if there was new evidence and sufficient information to draw boundary lines; 2) Surveys: most countries are conducting surveys. England is developing one for the channel. Ireland is not conducting a survey; 3) Ageing: although we examined ageing as part of our first meeting we have made little progress. There are large differences/discrepancies in age structure between stocks of King scallop. In the Baie des Seine scallops reach harvestable size at 2 years of age and the population is dominated by scallops <5 years of age. In contrast, in some areas around Scotland there are a large proportion of scallops aged 10+. Whether this is entirely an environmental/biological difference or due to different aging techniques influencing the results was discussed at the meeting. An international shell ageing exchange was proposed to further address the issue (see the future work plan section); 4) Seabed impacts: several presentations examined aspects of this, including bycatch, discard mortality and VMS data.

We examined the trends and developments in Fisheries (ToR 1, 2 and 3), summaries of available VMS Data and fishing effort, connectivity between stocks, and biological variables such as growth, discard mortality studies, and disease. Abstracts for each of the presentations are presented in Annex 3. The presentations are on the scallop working group site.

7 Revisions to the work plan and justification

The working group has collated information on the location of fishing effort, methods of surveying, population dynamics, biological parameters, fishery reference points and habitat impacts for the King, Queen and Icelandic scallops in ICES areas: 2a, 4a, 4b, 5, 6a, 7a, 7d, 7e/h, 7g, and 8, as outlined by the ToR's, as they stand now, based on the research of individual groups and organizations. Some information is sparse or lacking such as population dynamics and reference points by stock. The working group is now focusing on agreeing appropriate assessment approaches for key stocks. The need for this approach was discussed at length using the Baie Des Seines/English Channel and the Irish Sea/Isle of Man fisheries as case studies. Over the next meetings we will complete compilations of landings, effort, and fishing distribution data and derive basic indicators of stock status and spatial structure. We will also evaluate how stock assessment methods proposed by WKLife can be applied to scallop stocks, and the potential benefit of MPAs and European marine sites as sources of scallop recruitment in relation to ongoing connectivity studies.

The working plan for the next meeting is to compile, or obtain, data from ICES, by ICES rectangle of landings (t), fishing effort in kilowatt day or derived from VMS data, growth (von Bertallanffy equation parameters, and if possible size distribution), environmental patterns, bottom shear stress, water temperature and sediment maps. The problem of aging scallops was highlighted again in this meeting and the group agreed to send identified shells to the relevant staff/scientists at each of the laboratories and compile a table of measurement error. Currently there appears to be a large spatial variation in growth rate for the King scallops, which appears to reach commercial size in 2 years in the south but requires 6 or 7 years in the northern part of this range. However, this gradient is not constant and it is unknown how much of the variation is due to observer interpretation of ring counts. Our experiment is an attempt to quantify that bias.

8 Next meetings

2017/ACOM24 The **Scallop Assessment Working Group (WGScallop)**, chaired by Kevin Stokesbury, USA, will meet in Belfast 10th to the 12th October 2017, to

WGScallop TORs

1) Compile and present data on landings and fishing effort that allows the following data products to be produced at as high a spatial resolution as the available data allows in ICES areas 4, 6 and 7. Refer to WGScallop 2015 for methodologies
    a) maps of fishing pressure, fishing effort and landings
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2) Identify studies of larval source sink patterns to
    a) evaluate the potential value of protected areas as sources of scallop recruitment
    b) Identify populations that are important sources of larval supply
3) A) Review of current research underway on scallops, focusing on population dynamics, stock structure, life history and habitat impact of fisheries.

    B) Compare basic models derived from landings and effort to more complex models where they are available. (link to WKLife)
4) Estimate scallop discard mortality
5) Bycatch information, compile and report on the different survey/ICES rectangle.
6) Review the scallop aging experiment and determine best-practises for further aging work.

Annex 1: List of participants

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Annex 2: Recommendations

RECOMMENDATION	ADRESSED TO
Examine variations in ageing techniques	Variations in growth rate
Compile Fishing effort data (VMS data by ICES rectangle and/or kilowatt days)	Stockboundaries
Examine connectivity	Stockboundaries
Discard mortality estimates	fishing impact
Habitat/bycatch estiamtes	Habitat impact

Annex 3: Presentation Abstracts

1. Trends of international King scallop fisheries in 7d and 2016 survey in the Seine. (Eric)

1.1 2016 Bay of Seine French survey results

Each year, the French Research Institute for Exploitation of the Sea (Ifremer) conducts a Scallop stock assessment survey in the bay of Seine in July (Figure 1). The assessed area is divided in two, the Northern part (called "Proche Extérieur") is outside the French territorial waters, and the Southern part (called "baie de Seine") between the 12 miles limit and the French coast.

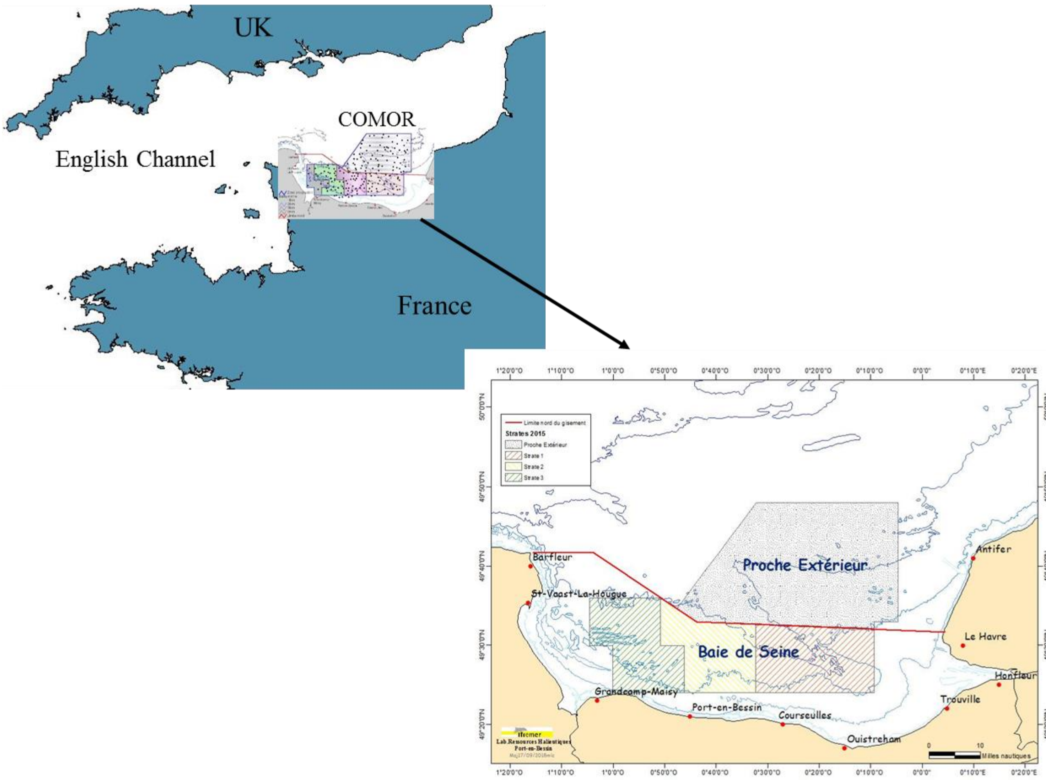

Figure 1: Bay of Seine (the red line marks the limit of the classified scallop ground, approximatively based on the French 12 miles limit).

The sampling gears are two 2m width French dredges with diving plate, one equipped with 72mm diameter rings, and the second with 50mm diameter rings. Selectivity and efficacy of the 2 different dredges are known. Estimation of abundance indices, exploitable biomass and growth are given as results.

1.1.1 Northern area "Proche Extérieur".

The abundance index of the 2 years old cohort, constituting the 2016 recruitment, is very good (24 288 individuals/mile), but oldest scallops (3 years and more, which have already been exploited the previous years) remains very weak (20.13) (Table 1 and Figure 2). The fishing effort by international fleet (France, UK, Ireland and Belgium) is too high relative to the exploitable biomass. The abundance index of the 1 year old cohort, constituting the 2016 prerecruitment, is also very good (254 09 individuals/mile), which indicates there may be a new good recruitment next year.

Table 1: Abundance indices observed in the area "Proche Extérieur", French COMOR survey July 2016.

	1 an	2 ans	3 ans	4 ans	5 ans	6 ans	7 ans
Indices 2005	26.50	98.64	15.38	1.38	0.47	0.33	0.46
Indices 2006	55.92	35.42	13.23	3.48	0.49	0.04	0.08
Indices 2007	97.51	66.81	7.99	4.53	0.71	0.14	0.08
Indices 2008	63.39	82.39	7.87	2.56	0.92	0.21	0.00
Indices 2009	31.71	68.38	9.96	2.55	1.44	0.58	0.24
Indices 2010	33.71	62.87	18.04	3.36	0.74	0.41	0.10
Indices 2011	486.40	107.55	18.85	5.39	1.30	0.53	0.38
Indices 2012	20.91	432.30	20.90	4.40	0.70	0.40	0.15
Indices 2013	4.88	60.53	79.79	5.41	1.16	0.78	0.38
Indices 2014	131.80	32.47	20.54	13.77	1.52	0.51	0.39
Indices 2015	271.24	173.94	4.50	4.80	3.25	1.11	0.32
Indices 2016	**254.09**	**242.88**	**17.40**	**1.40**	**0.99**	**0.27**	**0.07**

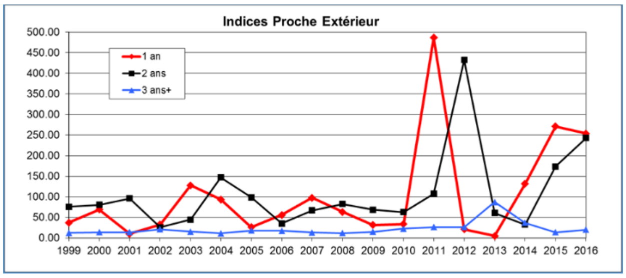

Figure 2: Trends of abundance indices in the area "Proche Extérieur", 1999-2016.

For the 2016–2017 fishing season, the estimated exploitable biomass at the beginning of the season seems high (15 024 tons) compared to the average 10 years biomass (10 779 tons) (Figure 3).

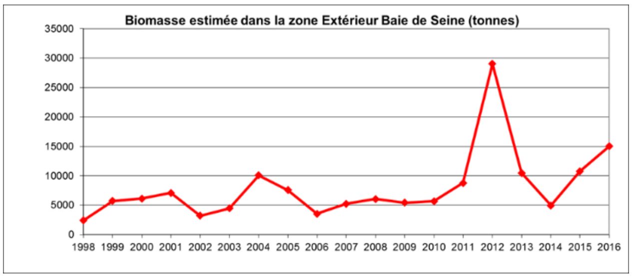

Figure 3: Trends of estimated exploitable biomass (tons) in the area "Proche Extérieur", 1998-2016.

The observed growth is weaker than average growth, except for ages 1 and 2 (Figure 4), and the population structure still unbalanced, with age 1 unexploited and age 2 recruitment representing most of the population (Figure 5).

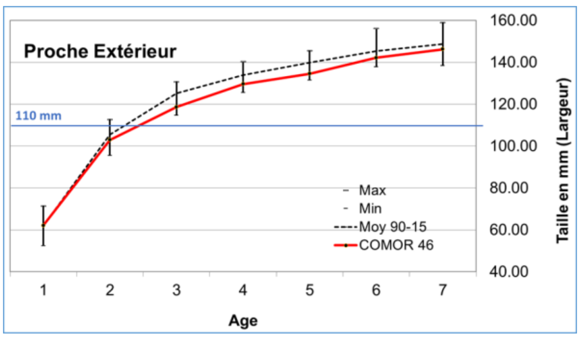

Figure 4: Observed growth in the area "Proche Extérieur", July 2016

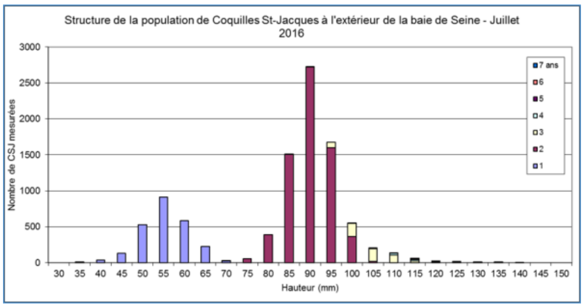

Figure 5: Population structure in the area "Proche Extérieur", July 2016

1.2 Southern area "Baie de Seine".

The whole seabed of the bay of Seine King scallop stock is located in the extended bay of Seine, only divided by the French territorial water limit. The trends observed during the assessment survey are the same in the both sides of the 12 miles limits. In the "baie de Seine", as in the "Proche Extérieur", the abundance index of the 2 years old cohort, constituting the 2016 recruitment, is very good (28308 individuals/mile), and oldest scallops (3 years and more, which have already been exploited the previous years) remains also weak (3504), but a little bit better than outside (Table 2 and Figure 6). As we observed in the offshore area, the situation for the abundance index of the 1 year old cohort, constituting the 2016 prerecruitment, is very similar, with the best abundance index ever seen in the time-series (70548 individuals/mile), which means a future high recruitment next year.

Figure 5: Population structure in the area "Proche Extérieur", July 2016

	1 an	2 ans	3 ans	4 ans	5 ans	6 ans	7 ans
Indices 2006	41.58	72.92	26.15	4.92	0.76	0.30	0.13
Indices 2007	41.56	45.43	14.28	7.02	2.09	0.19	0.28
Indices 2008	59.06	60.24	13.48	7.94	2.69	1.08	0.32
Indices 2009	104.51	75.84	14.20	3.87	1.81	0.88	1.23
Indices 2010	161.42	102.77	20.41	5.92	2.07	1.05	1.03
Indices 2011	333.87	193.66	26.35	8.37	2.45	1.02	0.56
Indices 2012	36.21	303.83	31.36	8.58	2.08	0.94	0.59
Indices 2013	3.12	93.00	99.30	16.02	3.31	0.71	0.32
Indices 2014	114.74	12.19	32.42	22.33	2.86	0.68	0.28
Indices 2015	279.64	197.73	5.72	8.34	6.29	1.32	0.39
Indices 2016	**705.48**	**283.08**	**27.05**	**4.40**	**2.27**	**1.02**	**0.65**

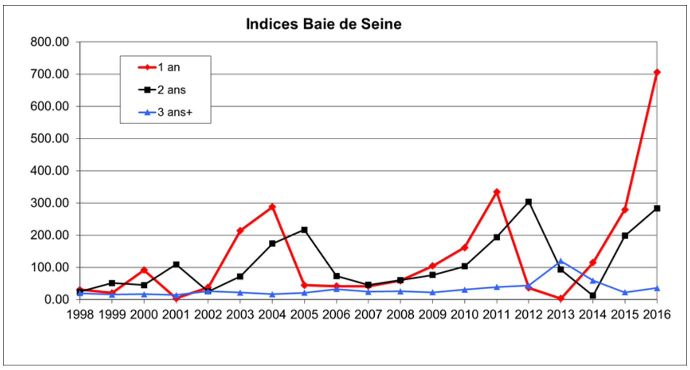

Figure 6: Trends of abundance indices in the area "Baie de Seine", 1999-2016.

For the 2016–2017 fishing season the estimated exploitable biomass at the beginning of the season seems high (20 334 tons) compared to the average 10 years biomass (11 667 tons) (Figure 7).

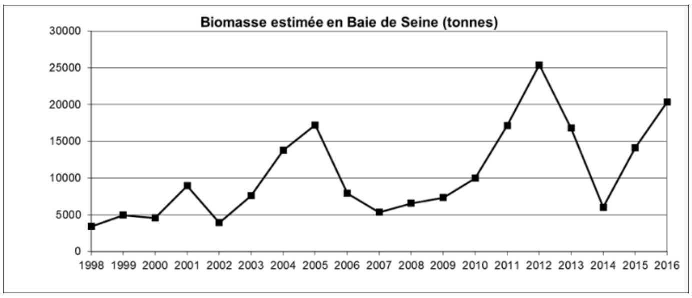

Figure 7: Trends of estimated exploitable biomass (tons) in the area "Baie de Seine", 1998-2016.

Growth (Figure 8) and population structure (Figure 9) observed in the area "Baie de Seine" are similar to those observed in the offshore area.

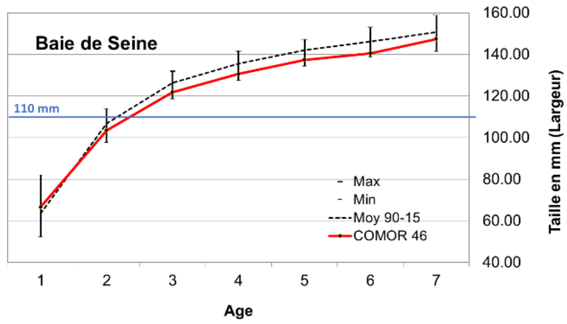

Figure 8: Observed growth in the area "Baie de Seine", July 2016

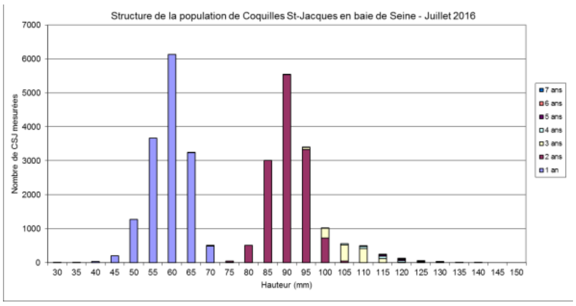

Figure 9: Population structure in the area "Baie de Seine", July 2016

2. Trends of international King scallop fisheries in 7d

King scallop is exploited in the Eastern Channel (ICES division 7d) by an international fleet, mainly constituted by UK and French scallops, and also recently by Irish boats, since 2012. Ten years ago, each fleet remained in its own territorial waters. But recently, because the lack of UE regulations (excepting the MLS fixed at 11cm in 7d), some nomadic boats coming from Scotland are exploiting the stock potentially all year long, and legally, King scallops just outside the French territorial waters. On the French side, the King scallop fishing is highly regulated for the French fishermen: fishing closure for all boats during summer, from 15 May to 30 September, limitation of fishing days per week, of fishing hours per day, limitation of number and size of boats – power and size limit –, high selectivity gears and limitation of dredges per boat. This led to a conflict situation in international waters just outside the French territorial waters in the North of the bay of Seine (Figure 10), the main fishing ground for the King scallop in 7d.

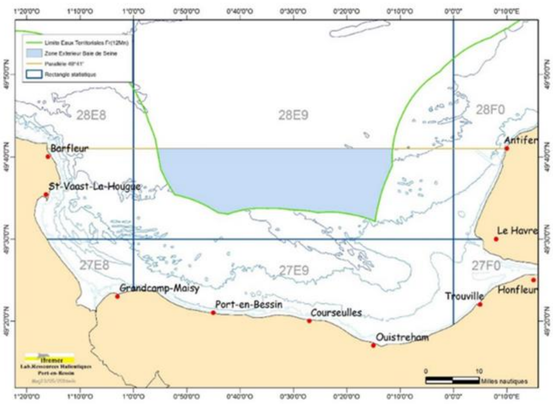

Figure 10: The Bay of Seine fishing ground (territorial French waters south of the green 12 miles limit line).

The landing trends of all fleets in 7d (Figure 11) from 2000–2015 show an increase of landings by the French fleet during the first part of the time-series (from 2000–2005) and a stabilization of landings around 15 000 tonness per year. The landings of UK fleets were very stable, around 2000 tons during the 10 first years of the time-series, and a real increase of landings in the early 2010's years. Landings of the Irish fleet are very low (some tonnes in 2004, and less than 500 tons/year from 2012–2015).

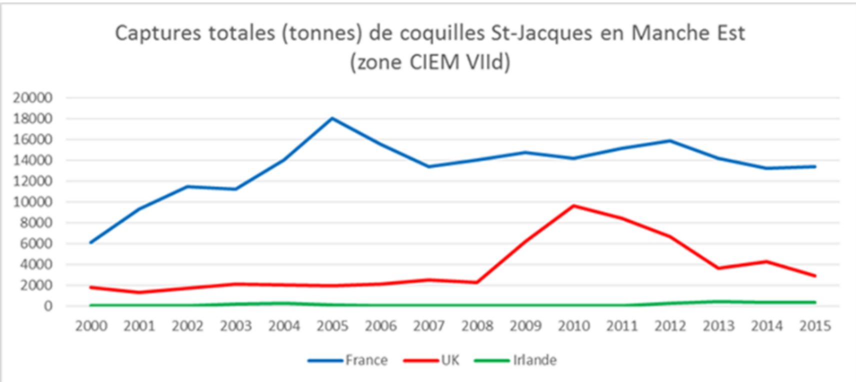

Figure 11: Total King scallop landings in 7d from 2000 to 2015.

Most of the French landings came from 2 ICES rectangles (27E9 which is entirely within French territorial waters and 28E9, in and out the 12 miles limit). These 2 rectangles represent between 40 and 60% of the total French landings made into the 7 division (Figure 12).

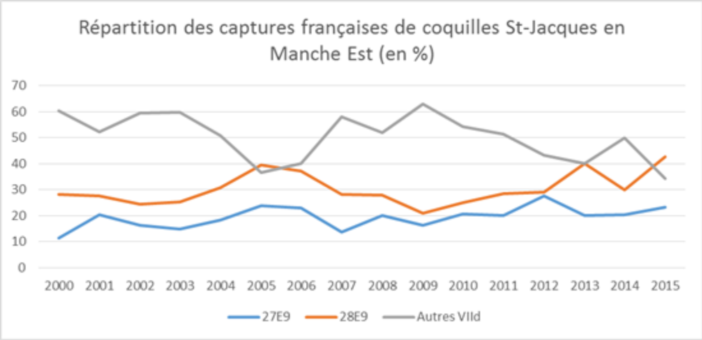

Figure 12: Percentage of French landings coming from 27E9 and 28E9 ICES rectangles, from 2000 to 2015.

UK landings coming from 28E9 are quite recent (Figure 13).

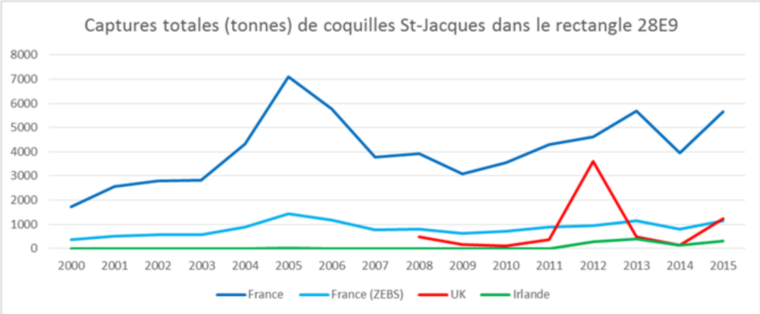

Figure 13: International landings coming from 28E9 ICES rectangles, from 2000–2015.

As noticed previously, King scallop fishing has a strong seasonal signal, in opposition of UK landings in offshore ICES rectangles (Figures 14a,d). Nevertheless, an opportunistic exploitation of the 28E9 rectangle by nomadic UK boats could be seen since the beginning of 2010's (Figures 15a,b).

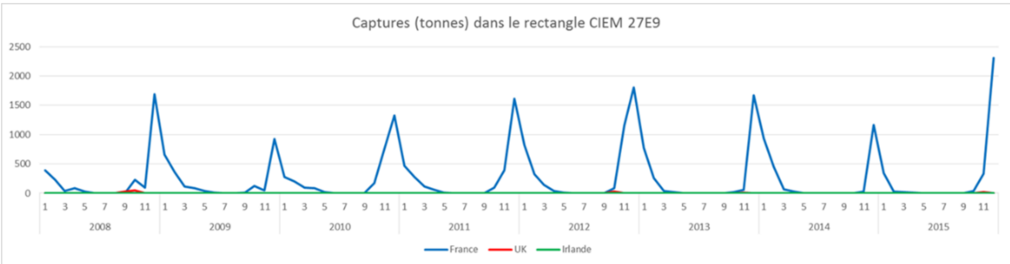

Figure 14a: International landings in ICES rectangle 27E9

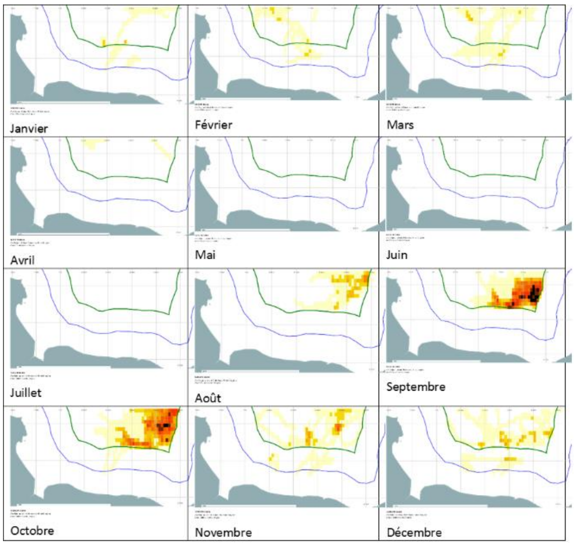

Figure 15a: Monthly space distribution of fishing effort of UE vessels (only gear=dredges ») in 2012.

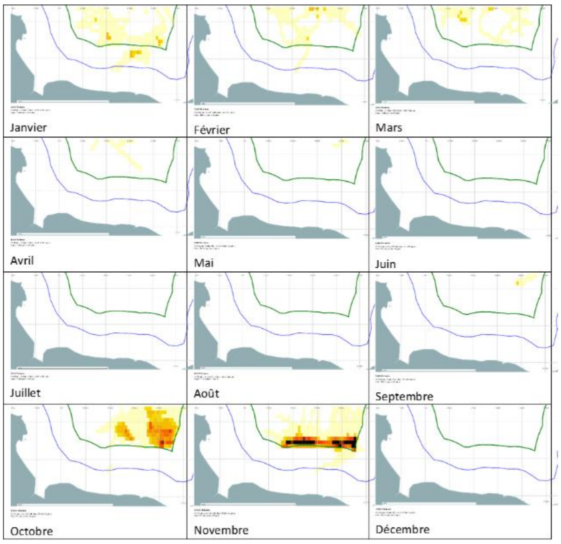

Figure 15b: Monthly space distribution of fishing effort of UE vessels (only gear=dredges ») in 2015

The French LPUE are globally increasing from 2000 –2015, especially since 2009 (Figure 16).

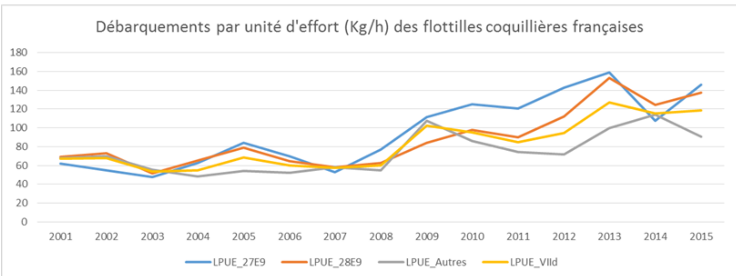

Figure 16: Trends of French LPUE from 2001 to 2015, all areas in 7d.

2. Queen scallops (*Aequipecten opercularis*) Faroe Islands.

Within the Faroe Islands territorial waters (ICES 5b) queen scallops (*Aequipecten opercular*i) are commercially fished. The main fishing grounds are located in the east and north of the islands. The fishery was initiated in the early 1970s in the eastern coast and early 1990s in the northern coast. In recent years the fishing activity has also extended to a fjord (Djúpini) situated in the northeast. The bulk of landings (>85%) is comprised of catches from the eastern area. Fishing for scallops is conducted by one single domestic vessel (30 m in length) using a double 12-feet dredge.

Landings and effort data are available from official statistical sources and logbooks respectively.

Since 1991 landings have fluctuated between 2300 and 6700 metric tonnes. Average tonnage from 1991–2015 is around 4100 t. Catch rates (CPUE, catch per hour) suggests no long term decline of the scallop fishery. The index fluctuates around 1500 kg/hour with no clear trend while fishing effort has decreased which may indicate an increase in dredge efficiency.

A swept-area survey was carried out in 1991 in the east and north coast. In 2012 and 2013 similar surveys were conducted in the northern area as well as in the northeast ford (Djúpini) respectively. Although age disaggregated data are sparse it suggests that growth is spatially dependant within and among the north and eastern areas. In 2016 an experiment with underwater camera was performed in fished and relatively unfished grounds to assess the effect of dredging on the seabed. Results of this study are, however, not yet available.

3. Iceland (*Chlamys islandica*)

A moratorium was put in place in 2003 on the scallops grounds in Iceland and that is still in place. Since 2014 the annual dredge survey targeting Iceland scallops (*Chlamys islandica*) on the main beds in Breiðafjöður has shifted to drop frame camera survey/mapping. During the last years of the dredge survey there was a reduction of days at sea and in 2012 and 2013 only southern and northern part of Breiðafjörður were surveyed respectively. The full dredge survey index 2006–2011 had dropped down to between 11-14 % of the average index of the years 1993–2000, prior to collapse of the stock. In the last two dredge surveys old scallops (~10 year) were dominant in the catches and recruitment was evident in several areas.

In 2014 a cooperation was established between the stakeholders and the Marine Research Institute in regards to increase the researches (partly funded by the industry in form of vessel time) and conduct experimental fishing. Two drop frame surveys were conducted in 2014, 146 camera stations were taken in April and 43 stations in December after a spell of experimental fishing. Around 80 drop frame stations were carried out in 2015 and around 150 in autumn 2016. The scope of the drop frame survey was to get an absolute abundance estimate on the common grounds and also to search for new beds and get a better coverage of the known beds. Few new beds and scallops in fishable densities in the inner part of the old grounds have been detected in the drop frame surveys. A link to the drop frame surveys can be found here: http://www.hafro.is/~jonasp/skel/

In the experimental fishing 280 tonnes were fished in 2014 in an area in southern part of the fjord. During winter of 2015–2016, 630 tonnes were fished on four distinct areas within Breiðafjörður. Each experimental area was split up further into roughly 1 km^2 rectangles. The fishing effort varied between areas and on the most heavily fished rectangles a decline in LPUE was observed.

4. Marine Scotland Science Scallop Dredge Survey 2016 overview

The marine laboratory has been carrying out dredge surveys for scallops for at least 35 years, formerly using commercial boats, but more recently its own research vessel which since 2008 has been the MRV *Alba na Mara*. The main aim of these surveys is to collect catch rate data for use in the stock assessment process. MSS conducts three scallop surveys per year, covering the east coast of Scotland, the west coast and Shetland with a possible 332 fixed stations. The station positions are based on historical fishing patterns and areas of suitable sediment from British Geological Survey sediment maps.

Spring loaded Newhaven type dredges are used on the surveys, with a total fishing width of 9 m. The starboard side has 6 x 9 toothbar and 80 mm bellyrings, similar to commercial King scallop dredges and the port side has sampling gear made up of 6 x 11 toothbar and 60 mm bellyrings, similar to that used for Queen scallop fishing. The latter sampling gear is utilised to catch undersized scallops and smaller bycatch.

At each station, the dredges are towed at a speed of about 2.5 knots for approximately 30 minutes and all King scallops are aged and measured. Other objectives include: assessing shell damage, collection and identification of bycatch including starfish, collection of samples for parasite, toxin and genetic research. On the 2016 surveys there were some additional objectives, including clapper shell collection for natural mortality estimation, marine litter monitoring and coverage of additional stations in Broadbay (an area closed to scallop fishing) and in a previously un-surveyed (but commercially fished) area of the West of Kintyre.

In 2016, a total of 210 stations were sampled and 28 900 scallops caught, with every scallop being measured, aged and assessed for damage. Some stations, located in newly designated Marine Protected Areas (MPA) where commercial dredging is banned, were not completed (although the impact of this on the survey index appeared to be relatively minor). The additional objectives were achieved or partially achieved despite a total of 11 days of fishing being lost due to bad weather or technical issues.

Vessel time has been requested, as usual, for three surveys in 2017 and the main objective will be the collection of data for stock assessment. The Marine Protected Areas may have an affect the survey design but new tows in other areas are also likely to be explored in future.

5. Trends in Scottish survey data

Dredge surveys of the major scallop grounds around Scotland have been carried out by MSS since the mid 1990s (partial surveys of the west coast began in the late 1980s). Over the years, different survey dredge widths have been used and catch rates are, therefore, standardised for both fishing time and dredge width and presented as numbers caught per hour per metre dredge width (N h-1 m-1). Indices for each assessment area are calculated by aggregating total catch-at-age numbers from both dredge types over all hauls and dividing by total duration (and dredge width).

Across the East Coast and North East assessment areas, few age three scallops were caught in 2016. The survey index at age three has also shown a decline in recent years in the west coast assessment areas although to a lesser extent. There are currently still a relatively large proportion of older scallops in the survey catches (in most of the assessment areas) due to strong year classes in the mid 2000s. Plots of the mean standardised survey catch rates show relatively good tracking of year-class strength, particularly for the North Sea survey (although the signals become more noisy in recent years). In addition, comparison with mean standardised commercial catch-at-age data shows relatively consistent signals. Typically, the North Sea survey appears to perform better about year-class tracking and shows greater consistency with the commercial data.

6. Trends in the abundance of bycatch in Scottish scallop dredge surveys 2000–2014

The bycatch data held in the Marine Scotland Science (MSS) scallop database, collected on MSS scallop dredge surveys from 2000–2014 (3763 tows) were collated and analysed. Data from earlier surveys (1994–1999) were not analysed due to variations in the bycatch data collection protocols in these years. Multivariate and univariate analyses were used to investigate the spatial and temporal trends in standardised abundance (N hr^{-1} m^{-1}) and species composition. It was found that 98% of tows contained bycatch. A range of fish and invertebrate species were caught, including several of commercial and ecological interest. When looking at community composition as a whole there was a significant difference in the bycatch assemblage between MSS survey areas (Scottish west coast, Scottish east coast and Shetland), but not between years. When looking at individual indicator species, temporal trends could be identified along with significant model effects of area, time and an interaction between the two. For example, the post hoc pairwise testing for Brown crab (*Cancer pagurus*) revealed a significant difference in the catch rates between survey areas, with the west coast displaying a significantly different interaction effect compared to the east coast and Shetland. This was due to a peak in the catch rates in the west coast from 2003-2006, followed by a decline in subsequent years. For Queen scallop (*Aequipecten opercularis*), the post hoc pairwise testing indicated significantly higher catch rates in Shetland, which was more pronounced since 2006. It is also possible to map the spatial distribution of bycatch species using standardised abundance and presence/absence data. The findings of this work could have applications for marine management and planning, where data on species distribution has become increasingly desirable. It could also give an insight into bycatch from commercial dredging operations.

7. Scottish king scallop fishery data

Marine Scotland Science collates landings data for eight assessment areas, which were defined on the basis of historical fishing grounds and known areas of scallop habitat. In 2015, the estimated landings from these areas totalled around 15 000 tonnes. Approximately two thirds of the landings are from UK vessels landing into Scotland and the remainder, which are largely from the Irish Sea assessment area, are by UK vessels landing into ports elsewhere in the UK (outside Scotland). The most important areas, in terms of total landings, are the Irish Sea, North East, East Coast, North West and West of Kintyre. Landings from the Irish Sea have increased steadily over time while in the other areas they have fluctuated over time.

Approximately 95% of the total Scottish landings (UK vessels landing into Scotland plus Scottish vessels landing abroad) are from dredge fisheries with the remainder taken by commercial divers. The dive fishery operates in the inshore waters of the west coast of Scotland and around Orkney. The scallop dredge fleet consists of over 100 vessels ranging in size from under 10 m to around 30 m in length. Smaller vessels tend to work locally in inshore waters while larger vessels are more nomadic and may move between fishing grounds around the coast of Scotland and the rest of the UK. The fleet characteristics are different for each assessment area, with the fishery at Shetland being characterised by smaller (under 15 m) vessels, in contrast to the North East area where landings are dominated by the over 15 m vessels (with over half of the landings taken by vessels greater than 20 m in length in recent years).

Scottish landings are reported from all around the coast of Scotland. Particular hot spots occur off the coast of northeast Scotland, at Shetland, in some parts of the west coast of Scotland and around the Isle of Man. VMS data from dredge vessels landings scallops filtered for appropriate speeds indicates high fishing activity in these areas. Further analysis of Scottish VMS data are planned for the future.

8. Modelling growth of scallops in Scottish waters

Scallop shell height at age data collected during Marine Scotland Science's scallop dredge surveys were used to investigate growth of the king scallop *Pecten maximus* in waters around Scotland. The data comprise 73 271 measurements from 15 033 individuals caught in 313 hauls on surveys between 1993 and 2014. A two stage modelling approach was adopted. Initially, data from each haul were modelled using a reformulated linear von Bertalanffy equation incorporating individual as a random effect to obtain estimates of the Brody growth coefficient K and H_∞. These estimates and associated variances were used as inputs in linear mixed-effects models to model the growth parameters, *K* and H_∞, against a suite of explanatory variables.

Depth was the only significant fixed effect retained in models of growth coefficient *K*, with higher values of *K* associated with shallower sites. The model of best fit for H_∞ included fixed effect terms for sediment particle size, assessment area, area latitude interactions and median age of individuals in the sample; higher values of H_∞ were estimated in samples of lower median age. It was suggested that this could reflect the selective removal of faster growing individuals in areas which are heavily fished. ICES statistical rectangle, included as a random effect, was significant in the model for *K* but not for H_∞. The year of survey which, included as a random effect, was not significant in models of either *K* and H_∞, but area /year interaction terms were and both these and survey year were retained.

Influences on growth varied geographically, but with little consistent pattern. Growth of scallops in Scottish west coast assessment areas appears to influenced by latitude and mean sediment particle size, whereas on the east coast assessment variation in H_∞ varies with depth and mean sediment particle size. However, the stability observed in growth characteristics over this longitudinal dataset suggests that the particular conditions responsible for growth patterns observed are persistent over time and significantly more influential than individual scallop effects. Close attention needs to be given to the sampling for growth studies for findings to be comparable across populations. A finer resolution of fishing effort data would allow the influence of growth characteristics, which are changing over distances of 10s of km, upon the fishery to be assessed.

9. Estimating Damage Related and Natural Mortality in King Scallops (*Pecten maximus)* in Scottish waters

The mortality rates, either natural or due to discarding, of king scallops, *Pecten maximus*, in Scottish waters are poorly understood and yet this information could be highly valuable to future stock assessments. An assumed natural mortality rate of $0.15yr^{-1}$ is currently used for all ages of king scallop in Scottish stock assessments. Discard mortality is typically thought to be low; however, few studies of mortality rates have been conducted in Scottish waters and this is an area which remains poorly understood. Using survey data, the proportion of king scallops damaged and unlikely to survive discarding was examined in Scottish waters. Approximately 5.7% of all king scallops caught had damage considered to be severe enough to cause mortality. Better understanding of discarded damaged king scallops in the commercial fishery is needed, as a similar value would represent an unaccounted mortality likely to affect stock assessment results. The percentage occurrence of clappers, empty paired valves of dead scallops still attached by the hinge ligament, compared to the number of live scallops captured can potentially be used as an estimate of the annual natural mortality rate. This study represents the first time this method has been explored for the king scallop in Scotland. The ratio of clappers to live individuals obtained in the survey was very low, possibly due to increased disarticulation of the hinges during the capture process. It was concluded that an adjustment factor would be required to account for the proportion of clappers separating during towing in order to obtain a more reliable estimate of the true clapper to live ratio. Furthermore, a good estimate of clapper separation time is also essential to the derivation of natural mortality rate from these data.

10. Northern Ireland Scallop Fishery

In 2015 over 1300 tonnes of scallops were landed into NI ports by 76 vessels with a first sale value of £2.7 million. Of the vessels which reported these landings, 45% were less than 12m and so have no VMS.

Between 2007 and 2015 scallops were landed into NI from 28 different ICES rectangles. In 2007 and 2008 ICES rectangle 37E4 was the most important, with landings from this area representing approximately 50% of all landings into NI. By 2015 whilst this area still provided the highest landings its importance in terms of the proportion of total landings had reduced with 26% of the landings made into NI coming from 37E4.

Northern Ireland Scallop Survey

For over twenty years AFBI have been carrying out an annual scallop survey around the North West Irish Sea. Between 2011 and 2015 the survey was extended to cover the majority of NI coast based on VMS activity. In 2015 the design of the survey was altered to provide random sampling of the areas. A 1.5nm^2 grid was weighted based on previous survey catches and fishing intensity from VMS. Using this, the variance within each area, in terms of survey catches, is examined prior to each survey to determine the optimum number of sampling station. The dredges used during the survey are four 75cm dredges. A mesh liner is placed in one of the dredges to retain juvenile scallops. All scallops caught are aged and total weight, length, height, gonad weight and muscle weight recorded. Bycatch is recorded as number and weight of each

The survey has found that Outer Belfast Lough typically has the lowest CPUE whilst the North Coast has the largest CPUE. Very few one and two year old scallops have been recorded during the surveys. At all areas, there have been returns of aged 10+ scallops in most years. The northern area of the Ards Peninsula has the highest average catch of aged 10+ scallops with an average of 20.1% of scallops caught in this area being older than ten years of age.

In order to determine the season in which a scallop was spawned, the width of the first growth band was measured. Scallops with large first bandwidths tend to represent those spawned in spring whilst small first bands represent scallops spawned in autumn. For some years there are two peaks in the width of the first band, representing spring and autumn spawned animals. Analysis of scallops from a single area show that in earlier years the primary peak in spawning is skewed to the right, with the main peak in first bandwidth being greater than 25mm. However, from the mid-90's there is a shift in the peak in bandwidth, to less than 25mm. The differences in growth between scallops spawned in spring and those spawned in autumn was compared for a fixed area (Figure 1). For the first 5 years growth of scallops spawned in autumn is lower than those spawned in spring. After this there appears to be no differences between the growth of the two sets of scallops. The outer Belfast Lough site tends to have the highest growth rate, whilst the North Coast and Antrim Coast have the slowest growth overall.

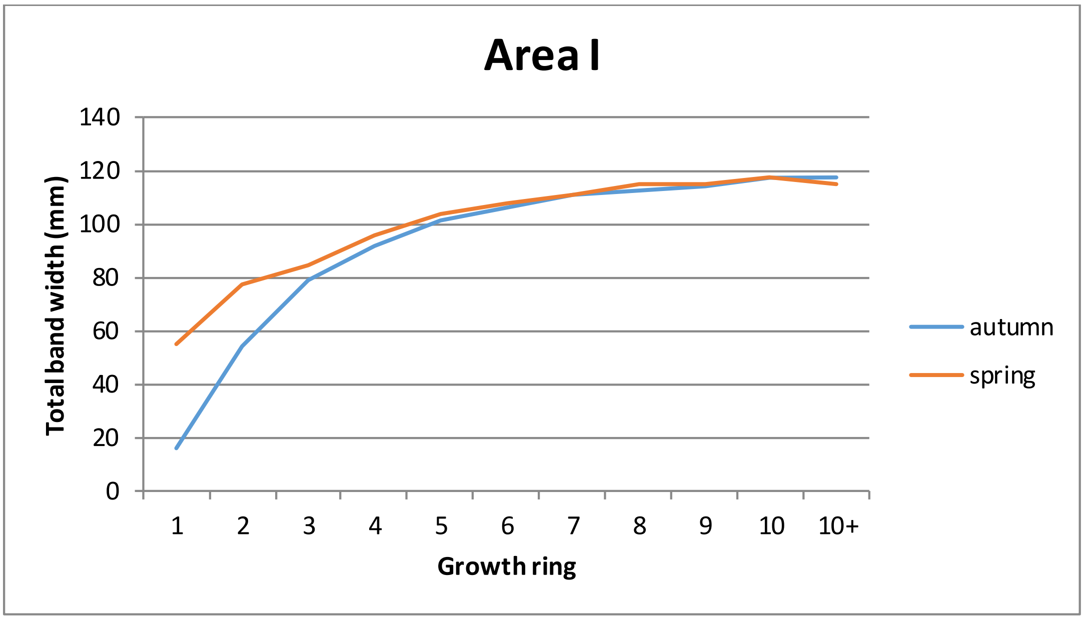

Figure 1: Growth of scallops from Area 1 separated into those spawned in Spring and those in Autumn.

New Project

AFBI have been awarded funding from Seafish to carry out a scallop larval dispersal background study. In 1999 a reseeding study carried out by C-Mar provided mixed results. Issues with this study included survival of the seed during transport to the relaying site, lack of predator control and continued fishing of the reseeded sites. Based on this study the NI Scallop Association approached AFBI to carry out work to determine optimal settlement sites for a new reseeding project. There are two questions to be addressed in this work

1. Which sites are the most suitable to reseed with scallops?

In order for reseeding to be successful the scallops must be retained in the area and show successful settlement. AFBI was examine 12 sites selected by the Scallop Association as well as examining areas already closed to fishing, such as SAC's, to determine the best possible sites for retention. The sites will be examined in terms of the ground type and hydrodynamics. The ground type of the indicated sites will be determined using the AFBI seabed habitat maps. It will also allow us to determine the potential area of each site which could be used to relay the scallops, estimating boundaries of the indicated sites. For example, the boundaries of the suitable habitat type could act as the boundary to the relaying site, or the boundary of a closed area would be a natural definition for the relaying site.

In addition the hydrodynamics of these areas will be examined. If the currents in the area are too strong then the re-laid scallop seed may be dispersed before it has time to settle and recess into the seabed. POLPRED (CS20 high resolution shelf model), which is an offshore based tidal computation and visualisation package, will be used to look at the currents in the area of the reseeding sites.

2. Where will the larvae from the reseeding sites settle and is this available for future fishing by the industry?

Using the sites which have been determined as suitable for reseeding, work will be carried out to examine the potential settlement locations of the scallop larvae produced by the reseeded scallops once mature. A literature review will be carried out to determine scallop spawning and larval characteristics such as time of spawning, duration which larvae are carried by currents, location in the water column, cues for settlement. This information will then be used to look at the hydrodynamics around the coast, using POLPRED, in relation to the potential reseeding grounds and the most likely direction of transport of larvae from the reseeding sites. The ground type of the possible sites will be examined to ensure that they are suitable for settlement.

In order for this work to be valuable to the industry the re-laid seed must source a site which is fishable by the sector. AFBI will work with industry to determine if the potential settlement locations are indeed already being fished or are suitable for fishing.

11. Queen Scallop Fishery and Stock Assessment update

The MSC certification for the Isle of Man queen scallop trawl fishery is currently in suspension as a result of both a decline in stock status and a continued lack of management conditions within the remainder of the biological stock unit. Landings data displayed by ICES rectangle (2010–2016) indicates that the only area that supports a substantial sustained fishery for queen scallops year on year occurs within ICES Area 27.7a, a less regular fishery occurs within 27.6a and a new fishery has emerged in 27.4a in 2016. Whilst the UK administrations are currently working towards a longer term objective of pan-Irish sea management of queen scallop stocks (with a consultation on management options due to be released in October 2016), Industry enacted a one month closure (May 2016) for the first time in 27.7a and 27.6a to try and provide protection to the stock during the spawning period. The closure was a success within 27.7a and 27.6a with no landings of queen scallops recorded during that month, however overall landings for the month were not reduced when compared from 2015 with a displacement of fishing effort to 27.4a.

The Isle of Man annual spring scallop survey took place onboard the R.V. *Prince Madog* in 25 April–8 May 2016 with a total of 49 stations sampled. Dredge cameras were trialled for the first time onboard the survey to provide a visual check of the gears functioning and to provide an insight into the efficiency of the gear in different habitats. The 2016 survey data indicated variable densities of queen scallops at different fishing locations but with generalised low densities of queen scallop recruits across the majority of the main fishing grounds. The stock assessment indicated that the median estimated biomass was lower for 2016 than for 2015. The corresponding scientific advice stated that there was no evidence that the stock could support any increase in TAC from 2015 and that should fishing occur in 2016 a more precautionary approach (i.e. lower TAC) should be adopted.

The Isle of Man queen scallop fishery for 2016 has 49 licenced vessels (2 of which are inactive). Of these vessels 9 declared for the dredge fishery and 40 declared for the trawl fishery at the start of the fishing season. Of the 40 vessels eligible to fish in the trawl fishery to date 31 have recorded landings this season. The fishery is monitored by Daily Catch Returns and an increased VMS polling rate with accelerated pings at 15 minute intervals. There was also a weekly vessel catch limit in place of 4200 kg (Weeks 1–10) and 2800 kg (Weeks 11 onwards). The average fleet LPUE for the fishery has seen a marked reduction in 2016 compared with previous years at almost all fishing grounds but in particular the West coast (the East coast fishing ground remains at the low level observed for several years). New research includes an industry led annual juvenile queen scallop recruitment survey using a 2 m beam trawl that was undertaken for the first time in 2016. Future plans include the introduction of artificial settlement structures within closed areas to try and promote settlement in areas where the natural settlement substrata may have been negatively impacted by fishing or other pressures in order to help enhance natural recruitment to the fishery.

12. Welsh Fishery

Independent surveys have recently restarted for Welsh water scallops, following on from three years of previous surveys (Lambert *et al*. 2014). Three further years of annual surveys are underway, which upon completion will result in a time-series of six years of survey data. The primary goal of the surveys is to obtain sufficient data to implement a stock assessment model. Key considerations for the model include the degree of age-structure and spatial differences in scallop biological parameters throughout Welsh waters. Other less biologically detailed models, such as surplus-production and delay-difference, will also be implemented to allow for a comparison of output estimation. The advice based on the model output will also have to consider the amount of dredging that could be tolerated by both the seabed and the benthic communities, and this is likely to incorporate environmental thresholds identified in previous work (Lambert *et al*. 2015a; 2015b; Murray *et al*. 2015).

There have also been attempts to improve a camera sledge design, and this is ongoing. It is hoped to be able to reduce the differences in abundance estimated from a camera sledge and dredges. This is with a long term view towards being able to conduct surveys solely by camera sledge at some point in future. Work will also be conducted to map commercial vessel fishing patterns and habitat data to be used as a proxy for scallop distribution. There are also longer term plans in place to conduct economic analysis of the Welsh scallop fishery.

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13. Development of indices of stock trends from VMS and Logbook data

Marine Institute, Ireland.

Logbook data describing the daily targeted catch of legal sized scallops and fishing time (hrs) are available at the resolution of ICES rectangle for all vessels over 10m in length for at least 10 years. GPS data, from vessel Monitoring Systems (VMS), on fishing location at 2hr frequency is available for all vessels over 15m for over 10 years and for all vessels over 12m since 2014. In some cases vessels under 12m also report fishing position. Although the VMS and Landings are reported at different temporal and spatial resolutions they can be combined to link landings and fishing time. Fishing events occur at speeds of <4knots and the VMS data should be filtered to exclude data above this limit and reported as the time between successive VMS records (dT). There is a close relationship between vessel length and number of dredges carried by the vessel. Nominal landings per unit effort ($LPUE_N$) can, therefore, be described as $kgs.dredge^{-1}.day^{-1}$, $kgs.dredge^{-1}.loggedhr^{-1}$ or $kgs.dredge^{1}.VMShr^{-1}$.

VMS data targeting scallop (Vessels carrying dredges and where catch composition is >75% scallop) can be used to map historic distribution of scallop fishing. This is likely to define the known distributional extent of commercially viable scallop beds. The annual distribution of scallop fishing provides an estimate of the annual footprint or pressure to which the stock is exposed although the footprint estimate is sensitive to the resolution (ping frequency) of the VMS data. Changes in the footprint can be incorporated into the Susceptibility estimate in Productivity Susceptibility Analysis (PSA) which can be seen as a risk score for fished scallop stocks. In the absence of other assessments it provides a means of monitoring risk of overexploitation.

Trends in $LPUE_N$ indices in the Celtic Sea are not consistent: $kgs.dredge^{-1}.day^{-1}$ increased from 2007–2013 and then declined; $kgs.dredge^{-1}.loggedhr^{-1}$ increased from 2005–2010 and declined thereafter; $kgs.dredge^{1}.VMShr^{-1}$ was stable from 2006–2013 and then declined. Total landings also declined. Further evaluation of data quality and the statistical properties of the data are required.

$LPUE_N$ can be standardised ($LPUE_S$) to remove trends that may be due to factors other than changes in the abundance of scallop. Likely factors to consider are fishing season (month), location (e.g. ICES rec within stock), ground type, vessel power, gear type, vessel plotting systems, wind speed and tidal strength.

Increased frequency of VMS and catch reporting, as implemented in some inshore VMS systems for smaller vessels, potentially allows reconstruction of precise vessel track information and the landings associated with that track. As the number of dredges can be predicted from vessel length the swept-area associated with a given catch could be estimated. Raising for gear efficiency would then allow absolute estimates of the abundance of the component of the stock above the minimum landing size to be estimated and provide survey type information based on a much higher volume of data than can be achieved from survey. Changes in biomass could be tracked seasonally and be used to inform near real time management.

14. Fleet Dynamics in the UK King Scallop Fishery

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The king scallop (*Pecten maximus*) dredge fishery is one of the fastest growing and most profitable fisheries in the United Kingdom (UK). However, the sustainability of this fishery is largely unknown and there are increasing concerns over environmental impacts and conflicts with other fisheries. Management of the UK king scallop fishery is relatively undeveloped; mainly focusing on gear restrictions at present, with some effort control for the largest vessels (> 15 m length). Like management regimes in other rapidly developing fisheries, it appears to be playing catch-up with changing fleet activities. One of the key issues potentially threatening the sustainability of the fishery is the impact of roving vessels. A criticism of roving vessels, which move freely between scallop grounds around the UK, is that they may have less incentive to adhere to local management practices and that their lack of local knowledge may increase conflict with other fisheries. This study examined fleet dynamics in the UK scallop fishery using Vessel Monitoring System (VMS) data and describes a method to dissect the fleet into local and roving vessels based on the total number of scallop grounds visited in the 2015 fishing season. Approximately half (120) of the observed vessels were defined as roving, that is they moved between at least two major regions around the UK during the year. Patterns and proportions of roving were distinctly different between vessels originating in the different UK nations. A Generalised Linear Model (GLM) indicated that engine size (kw) was the most significant predictor of a vessels roving characteristics and therefore the degree of roving between UK scallop grounds. The current scallop fisheries management regime appears to be both allowing and encouraging vessels to rove. We suggest tightening regulations on roving vessels in inshore areas, particularly with 6 miles of the coast, and harmonizing management measures around the UK outside of 12 miles. Refinement of the current effort limitation scheme for larger vessels could also help separate the fleets. This combination of measures would be an important step in improving the sustainability of the UK scallop fishery and reducing conflicts with other sectors.

15. Connectivity across scallop beds in the Irish and Celtic Seas

Marine Institute, Ireland.

Larval dispersal simulations were undertaken in the Irish and Celtic Seas to assess the level of connectivity between scallop beds in the area. The work is ongoing. Connectivity across five scallop beds (northeast Celtic Sea, south Irish Sea, Cardigan Bay and Liverpool Bay) was estimated annually for years 2011–2015.

The Ichthyop model was used to interface with archived ROMS model output files which contain arrays of current vectors and temperature and salinity data at 3 hour intervals at resolutions of 1.2–1.5km in the horizontal and with up to 40 vertical layers.. Current vectors, from ROMS output, integrated the effects of coastal topography, depth, wind forcing, freshwater inflows and solar heating on current strengths and direction within grid cells in the model. ROMS output faithfully reproduced salinity and temperature fields observed from satellite data.

Simulated larvae were introduced to Ichthyop by subsampling vessel monitoring system (VMS) data. The VMS data were assumed to be a proxy for the distribution and relative abundance of adult scallop and therefore represented locations from which larvae would be introduced to the water column during spawning events.

Larvae were treated either as passive particles with neutral buoyancy or particles which migrated vertically on a 24hr period between near-surface waters (night) and 20m depth (day). This, on average, retained larvae above the thermocline in areas of stratified water.

Simulations were initiated on 1 June of each year and ran for 40 days. This presumed that spawning occurred during June throughout the area and in all years 2011–2015.

Outputs from Ichthyop are in the form of NETcdf files. R scripts were developed to extract and report the outputs including conversion to shape file format for use within GIS, reporting of depth distributions of larvae during simulation, tracking individual larvae and drawing polygons describing the distribution of dispersal.

Results indicate that there is limited connectivity across the 5 scallop beds studied with a high level of self-recruitment. There is no exchange of larvae from the eastern Irish Sea south to other beds. There is no exchange of larvae from the Celtic Sea north into the Irish Sea. Larvae may be transported from the south Irish Sea into the Celtic Sea. There is some east west exchange of larvae between the south Irish Sea and Cardigan Bay. The south Irish Seabed is at highest risk of limited larval supply. Interannual differences in the level of larval exchange across beds are evident.

Future developments

Seawater temperatures during larval development vary by about 4°C between areas depending on whether the water column is mixed or stratified. This difference is expected to have very significant effects on larval lifespan although the parameters for a temperature development rate function for scallop are not well known. Larvae should therefore be competent to settle at different number of days depending on the temperature history they have experienced during the simulation and should be dropped from the dispersal simulation when they have experienced a given amount of temperature i.e. physiological rather than chronological age should determine the duration of time a given larvae should occur in the simulation.

Spawning season may vary annually and the most suitable time(s) to initiate the dispersal simulation should therefore consider the gonad development and readiness to spawn. As the simulations are necessarily done retrospectively on archived ROMS files a retrospective set of seasonal gonad development indices would ideally also be available to inform the timing of the simulations.

Larval vertical migratory behaviour has a significant effect on dispersal; this is likely to be either tidally timed or occur on a diel cycle in response to changes in light intensity. Studies to identify larval depth distributions and behaviour would be important to inform future simulations.

Correlations between the expected regularity of larval supply to different beds and age class structure of scallops on these beds could be investigated when a time-series of larval supply estimates have been produced. This would indicate whether or not variability of larval supply is a significant contribution to recruitment variability.

16. Survey of king scallops (*Pecten maximus*) for the presence of Apicomplexan parasite in the Scotland

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The King scallop, *Pecten maximus*, is the second most valuable commercially exploited mollusc in Scotland with landings fluctuating between 9000 and 10 000 tonnes over the last decade. The majority of the landings in the UK are exported to France, Italy and Spain with an export value of £90 million in 2012.

An Apicomplexan-like parasite was associated with abnormal mortality in Iceland scallops (*Chlamys islandica*) and consequent collapse of the stock. Although no mortality records were reported in Scotland, the Icelandic researchers found an identical parasite on Scottish scallops during a research study. The prevalence was high but light infestations were observed. Following these reports a concern regarding the health of wild scallops was raised by the industry and a survey was performed. Samples from the Shetland Islands, west and east coasts of the Scottish mainland were taken for screening of parasite presence and recording of macroscopic changes within the adductor muscle. All scallops showed good condition, meat colour was white and no macroscopic changes in the abductor muscle were observed. The prevalence of the parasite was high in all areas (Shetland Isles 87%, west coast 42% and 78% and east coast 76%) but with light infestations. The presence of the Apicomplexan-like parasite was confirmed by PCR and DNA gene sequencing resulted in 100% similarity to the previously reported Icelandic parasite. Histopathology examination revealed no lesions in the tissues. However, clusters of parasites were observed in the adductor muscle from scallops collected from the 2nd trawl on the west coast (3/27) and also from the east coast scallops (10/27). The histology also revealed minor muscular degeneration limited to the fibers at the vicinity of the parasite clusters.

In summary, the Apicomplexan-like parasite seems to live commensally, i.e. at low levels of infestation. It appears that the parasite may not cause any harm to the host, the scallop, but further investigation would be required to categorize the parasite. It also would be of great interest to understand the life cycle of the parasite; including factors influencing the survival of this parasite and the impact of a potential disruption of the equilibrium between host/parasite interaction in relation to the health of the scallop and consequent effects on meat quality.

17. Mortality assessment of Atlantic Sea Scallops (*Placopecten magellanicus*) from gray meat disease.

Megan M. Levesque, Susan D. Inglis, Sandra E. Shumway, and Kevin D.E. Stokesbury

The sea scallop (*Placopecten magellanicus*) (Gmelin, 1971) fishery is the most valuable wild scallop fishery in the world. Landings are primarily adductor muscles, which are ideally creamy white and firm. Recently, an increasing number of dark brown to gray, flaccid and stringy-meats, have been caught in areas of Georges Bank and the mid-Atlantic, causing concern in industry and management. The mortality of gray-meat scallops was investigated, and an anaesthetization procedure was developed allowing assessment of meat color in live scallops for laboratory experiments. The mortality rate of gray-meat scallops compared to white-meat scallops was tested. Gray-meat infection was swift and fatal; 26 of the original 28 gray-meat scallops died, while only one of 28 white-meat scallops died. The gray meat condition was clearly associated with apicomplexan parasite infection intensity. Gray meat scallops were identified visually, with image analysis computer software, and cell counts of apicomplexan nuclei. Secondary infections and stressors, including the effect of senescence, boring worm (*Polydora* sp.), and boring sponge (*Cliona vastifica*), were examined. Shells exhibiting high levels of boring sponge and worm damage had significantly higher incidence of gray meat scallops. The prevalence of gray meats in a scallop population changes the shell-height: meat-weight relationship and the estimates of natural mortality and fishing effort used in stock assessments. Understanding the impacts of this disease and how to manage the fishery in its presence is important for the future of the fishery.

Levesque, M.M., S.D. Inglis, S.E. Shumway, and K.D.E. Stokesbury. 2016. Mortality Assessment of Atlantic Sea Scallops (*Placopecten magellanicus*) from Gray Meat Disease. J. Shellfish Res. 35:295-305.

18. Norway (*Pecten maximus*)

(submitted by Strand Øivind who was unable to attend the meeting; for more detail please refer to Duncan et al. 2016 "The European scallop fisheries for *Pecten maximus, Aequipecten opercularis, Chlamys islandica*, and *Mimachlamys varia*. In Scallops Biology, Ecology Aquaculture and Fisheries. 3rd Edition Shumway and Parsons. Elsevier Amsterdam).

Exploitation of *Pecten maximus* in Norway has primarily been impeded by the unfavourable bottom conditions for dredging. Early dredging attempts yielded low returns, due mainly to rough bottoms and an abundance of seaweed that filled the dredges in only short tows (Wiborg and Bøhle 1974). Since the 1960's, SCUBA diving has been the common commercial harvesting method and the harvest by leisure divers has probably been extensive in some areas along the coast (Strand and Vølstad 1997).

A commercial diver-fishery was developed during the early 1990's in the main fishing areas west of Trondheim (64°N), and data on catch appeared from a statutory marketing data. Since 1999 the catch has been 400-800 tonnes with a value of 2-3 million Euro.

Since the fishery developed, the possibility of overexploitation of the harvestable stock has been an issue of concern among the numerous harvesters. The fishery was initially unregulated, although the sale of scallops was regulated through licensed distributors. The increase in diver participation in the scallop fishery 1998–2000 incited the Norwegian Labour Inspection Authority to set new certification requirements for commercial scallop divers. This restricted the recruitment of diver-fishermen and contributed to regulating the fishing effort. Based on input from a reference group representing industry, management authorities and research, a minimum landing size of 100 mm shell length was implemented in 2009 for both commercial and leisure catches. Suggested management measures on the introduction of closed areas were rejected based on cost-benefit considerations of enforcement and an appraisal of the existing rotational fishery between areas observed by the main harvesters. The anecdotal experience was that the harvestable stock has recovered after 2-4 years, although 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.

Data on individual diver catch per dive (CPUE) has been extracted from logbooks during the period 2003–2011 (Strand *et al*., 2015). In a diver-fishermen team a diver may catch 150–300 kg scallops per day (3–4 scallops per kg), 3–4 days a week. The individual diver catch efficiency tends to increase over several years until it levels out and is believed to be more regulated by scallop abundance on the beds. Individual diver catch efficiency is intended to be developed as indices of stock development and assessment of the self-imposed rotational exploitation strategy in the diver-based fishery.

19. Data Cells: an example of our request.

What the requested information will be used for

The data will be used for exploratory analyses and stock assessment in the scallop assessment working group.

WGScallop request that the following data call be issued with a delivery date of no later than 28 February 2017.

Outputs

The output of the benchmark workshop is to agree with specific datasets and stock assessment methodology for each stock to be used to provide fisheries management advice.

How to report data

Landings and effort data should be provided on a monthly basis from January 2007–September 2016 (inclusive) and imported into InterCatch. Ensure that the format and métier/fleet definitions are exactly the same as detailed below.

Geographical and temporal scope.

All ICES rectangles in subdivision 4, 5, 6, 7, 8.

1 January 2007 to 30 September 2016.

Pecten maximus

Landings (tonnes) and directed effort (KW days, for records where *P maximus* >50% of landings) by ICES statistical rectangle, month and Métier

Métier to be one of:

Dredge (DRG_MIS_0_0_0_all)

Beam Trawl (TBB_DEF_70-99_0_0_all and TBB_DEF_>=120_0_0_all)

Others (MIS_MIS_0_0_0_HC)

Aquipecten opercularis

Landings (tonnes) and directed effort (KW days) for records where *A opercularis* >50% of landings) by ICES statistical rectangle, month and Métier

Métier to be one of:

Dredge (DRG_MIS_0_0_0_all)

Otter trawl (OTB_BIV_85_100_all)

Others (MIS_MIS_0_0_0_HC)

Timing

The deadline to deliver the data is 28 February 2017.