Centre for Environment Fisheries & Aquaculture Science

Cefas

*World Class Science for the Marine and Freshwater Environment*

# Scallop Sentinel Survey Protocol

## Summary Report

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**Issue date:** 10/04/2017

# Cefas Document Control

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| Date submitted: | 10/04/2017 |
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| Quality control by: | Stephen Mangi |
| Approved by and date: | Stephen Mangi 10/04/2017 |
| Version: | V2.0 |

| Version Control HIstory | | | |
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| Author | Date | Comment | Version |
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# Executive Summary

The aim of Workpackage 3 of this Fishers-Science Interface Programme (FSIP) was to co-design a workable protocol for industry sentinel surveys for Channel Scallop fisheries. The funding received has allowed detailed participation of fishing industry members in the design and planning of the scallop survey activities in the English Channel. This work has been a vital part of a broader initiative between industry, fishery managers and government scientists to co-develop a stock assessment program for England's highest value fishery.

When initially conceived, the FSIP work was looking towards developing a fishery dependent data-stream along the lines of sentinel surveys. However, the concurrent genesis of the broader industry-governement initiative necessitated a slight change in focus to avoid duplication or redundancy of the intended work within this workpackage. The work therefore focussed upon facilitating the involvement of skippers and other industry members in active workshops intended to co-design the scallop surveys to better understand the rationales and needs of both industry and science alike.

The fruits of this process were borne out in the first dredge scoping study, which although the survey was not funded by the Seafish Strategic Investment Fund, is a fundamental part of the overall project and is therefore also described in this report.

The report details the activities undertaken in the two workshops funded by this project along with the Cefas input into the industry' scallop seminar which was attended as part of this work.

# Introduction

Fishing into the Future (FITF) was funded by Seafish through the Seafish Strategic Investment Fund to conduct a co-design process in collaboration with the Channel Scallop Fishery (CSF) to devise a sentinel survey/fishery that meets the needs of fishermen, science and management. Sentinel refers to the long-term use of commercial fishing gear when monitoring the fisheries akin to a 'keeper', 'guard' or 'watchman'. In terms of fishery management, sentinel surveys can assist to report on the current status of the stock, feeding back into management processes to oversee the status of the fishery.

Historically, sentinel fishery surveys are seen to provide a collabortive platform to promote communication, trust and information exchange between the involved partners of fishery scientist, manager and fishing industry stakeholders.

In recent years, there has been continued dialogue between the Scallop industry and the government body Defra (Department for the Environment, Food and Rural Affairs) regarding the needs for stock assessment of the Channel Scallop fisheries. The CSF has also been involved in wider stakeholder discussions about management of the stock in terms of fishery access and ownership.

Proposals for sampling currently include biological sampling of the fishery, dredge and TV survey which is being undertaken by Cefas (Centre for Environment, Fishery and Aquaculture Science). Sentinal industry-led commercial sentinel dredge surveys could be utilised to fill data gaps and provide wider survey coverage that would benefit the scientific program,  management and fishermen alike.

# Workpackage 3 Deliverables

Fishing into the Future was funded to conduct a co-design process in collaboration with the CSF to devise a sentinel survey/fishery that meets the needs of fishermen, science and management. The overarching objective was to co-design a workable protocol for industry sentinel surveys for Channel Scallop fisheries. The Lead partner to FitF was Cefas and key partners and participants were anticipated to include the Scallop association, SWPO, MacDuff Shellfish, Defra, Bangor University, EDF, and WWF-UK. The introduction into the project was given through the Sentinel survey presentation from Jim Masters, below.

To announce the start of the process in March 2016, a briefing paper was provided to give background and context on the project (see Annex 1). At the onset, the aim was to engage with the industry and the Defra co-ordinated group as it was envisaged that the two had similar aims in setting up industry-participation in survey design and scallop assessements. Workshops, followed by the set up of a Scallop Project, were considered the most suitable forum for the survey design discussions.

# Scallop Sentinel Survey

The project objectives and deliverables were further outlined in the FITF workpage described in Table 1 below.

**Table 1.  Work package 3: Sentinel Survey Workshops**

| ***Objective*** | | | |
|---|---|---|---|
| To co-design a workable protocol for industry sentinel surveys for Channel Scallop fisheries. | | | |
| *Sub-objective* | *Methods (how this will be achieved)* | *Outcomes* | *Deliverables* |
| *3.1 Establish industry support and buy-in to co-design process and plan.* | • FitF to convene initial meetings, conversations and engagement to secure industry buy-in to the co-design process.<br>• FitF will draw up a plan outlining timelines and milestones for the co-design process. | • All participants and partners are comfortable with their role within the co-design process.<br>• All participants are supportive of the co-design process and are able to contribute.<br>• All participants and partners are aware of milestones and timescales for the process. | **D3.1:** ‘Co-Design process’ plan. |

| | | | |
|---|---|---|---|
| *3.2*<br>*Co-design an industry-based pilot sentinel survey.* | • Scientific, industry and management authorities will co-design a workable survey protocol that includes the need fill information gaps in relation to stock distribution and densities and the incidence and severity of bycatch and habitat impacts.<br>• The work will build on information from a recent Defra funded study on options for assessing scallop stocks will be used to inform discussion and development of specific trials. | • A basis for industry-based monitoring of the scallop fishery to support informed management and provide evidence for other sustainability initiatives such as MSC certification.<br>• Enhanced industry reputation through taking responsibility for the data/ information needed to demonstrate their sustainability credentials. | **M3.2a:** Meetings on the design of survey protocol.<br>**D3.2a**: Draft Report on survey protocol options. |
| 3.3<br>*Produce recommendations for further action, including training needs, pilot trials and sources of additional funding.* | • The design of the survey will pay specific attention to developing the feedback mechanisms that promote and sustain industry buy-in (feed in to WP3).<br>• The training requirements needed for industry to undertake the survey will be identified and documented. It is anticipated that these may contribute to efforts by FitF to establish training courses on science and sustainability | • The combined outcomes from this WP provide the basis for further actions, project development and delivery in order to operationalise the sentinel survey.<br>• WP delivery feeds directly into and informs WP 1 and WP3. | **D3.3:** Final report to present recommendations for action and water-based trials. |

## Work Package sub-objective deliverables

Table 2 outlines the deliverables associated with each of the sub-objectives of the work package. As a large proportion of deliverable was associated with the workshops, minutes and summaries of the workshops are attached as appendices.

**Table 2**. Summary of deliverables and outcomes against sub-objectives

| ***3.1 Establish industry support and buy-in to co-design process and plan (Workshops)*** | | | |
|---|---|---|---|
| **Activity** | **Dates** | **Location** | **Output** |
| **Workshop with Industry** | **19th Jul 2016**<br>**Cefas staff**<br>Ewen Bell (Senior Scientific Advisor)<br>Andy Lawler (Shellfish Specialist) and<br>Dave Palmer (Bivalve Specialist) | Brixham | 1 day meeting, 2 days travel, preparation and post workup<br>Full meeting minutes are given in Appendix 1. |
| **Industry Seminar** | **10-11th Oct 2016**<br>**Cefas staff**<br>Ewen Bell<br>Andy Lawler | Brixham | 2 days seminar, 2 days travel, prep and post workup<br>Seminar slides are attached in Appendix 2. |
| **Workshop with Industry** | **2nd Mar 2017**<br>**Cefas staff**<br>Ewen Bell<br>Andy Lawler | Brixham | Full (draft) meeting minutes are given in Appendix 3. |
| **D3.1: Co-Design process plan output** | **Cefas staff**<br>Ewen Bell<br>Andy Lawler<br>Dave Palmer | | See Appendix 4.<br>Output also further evolved into the Scallop stock assessment Project Steering Board<br>Timelines and milestones outlined as part of the Project Steering Board committee. |

| ***3.2 Co-design an industry-based pilot sentinel survey.*** | | | |
|---|---|---|---|
| Industry-based survey designed and performed | 5th – 13th Nov 2016<br>Andy Lawler<br>Chris Barratt (Shellfish Team Leader) | Eastern Channel | Performed on Fishing Vessel Sylvia Bowers.<br>Summary survey report in Appendix 5. |

| 3.3 ***Produce recommendations for further action, including training needs, pilot trials and sources of additional funding.*** | | | |
|---|---|---|---|
| Set up of Scallop stock assessment Project Steering Board | Scallop Project Board Steering group set up on 19th July, 2016 Membership provided in Appendix. | | Scallop Project Board Steering group set up on 19th July, 2016. Regular meetings have followed and significant input has been made into the design and feedback from industry on the senitel survey and scientific survey design and implementation. |
| Additional funding obtained from EMFF | Additional funding applied in Sep 2016. | | EMFF approval for matched funding into 2017/2018 received in Feb 2017. |

The workshop naturally led into the development of the Scallop stock assessment steering board, set up to continuously input into the development of the stock assessment surveys. The steering board members (listed in Table 1 below) include and represent the majority to the fishery and fishery organisations and Steering group meetings are held immediately after the biannual SICG meetings.

**Table 3.** Scallop stock assessment Project Steering Board (PSB) membership list.

| Name | Organisation |
|---|---|
| Andy Lawler | Cefas |
| Andy Scott | Macduff Shellfish Ltd |
| Bill Brock | SWFPO |
| Ewen Bell | Cefas (via Skype) |
| Foster Gault | Seafood Ecosse (and Scallop Association) |
| George Jack | Whitelink Seafoods Ltd (and Scallop Association) |
| Hazel Curtis - Chair | Seafish |
| Helen Hunter | Defra |
| Iain Spear | Coombe Fisheries Ltd (and Scallop Association) |
| Jim Portus | SWFPO |
| John Denbow | SWFPO (and Scallop Association) |
| John McAlister | SWFPA |
| Juliette Hatchman | Macduff Shellfish Ltd |
| Sarah Pilgrim-Morrison | Macduff Shellfish Ltd |
| John King | West Coast Fisheries Ltd |
| Stuart King | West Coast Fisheries Ltd |
| Iain Young | SWFPA |
| Karen Vanstaen | Cefas (via Skype) |
| Keith Scholfield | Seafalke Shipping Ltd |
| Mike Park | SWFPA |
| Richard Hards | NSFPO |
| Nathan de Rozarieux | Falfish (and Scallop Association) |
| Tom Nicholson | TN Trawlers and Scallop Association |

**Table 4.** Scallop stock assessment PSB meetings

| Scallop stock assessment Project Steering Board | | | |
|---|---|---|---|
| **Scallop stock assessment Project Steering Board** | 16-Aug-2016<br>Ewen Bell, Senior Scientific Advisor<br>Andy Lawler, Shellfish Specialist | London | Full meeting minutes feeding back into SICG meetings and Sentinel survey design |
| **Scallop stock assessment Project Steering Board** | 20-22-Sep 16<br>Ewen Bell, Senior Scientific Advisor<br>Andy Lawler, Shellfish Specialist | Edinburgh | Full meeting minutes feeding back into SICG meetings and Sentinel survey design |
| **Scallop stock assessment Project Steering Board** | 8-Dec-2016<br>Ewen Bell, Senior Scientific Advisor<br>Andy Lawler, Shellfish Specialist | London | Full meeting minutes feeding back into SICG meetings and presentation of Sentinel survey |
| **Scallop stock assessment Project Steering Board** | 16-Mar-2017<br>Ewen Bell, Senior Scientific Advisor (Remote)<br>Andy Lawler, Shellfish Specialist | Edinburgh | Full meeting minutes feeding back into SICG meetings and presentation of Sentinel survey report |

# Discussion

# Annex 1. Sentinel Surveys Briefing Paper (Jim Masters

## Issue

The Channel Scallop Fishery (CSF) is looking for an accurate, ongoing stock assessment to ensure management takes account of the current state of stocks at any one time. The co-design of a ‘Sentinel Survey’ could allow the scallop fishery to contribute invaluable data to the management process. Collaboration with the fishing industry at every stage of the programme will be key to its success.

# Background

Since the well-publicised collapse of NW Atlantic cod stocks in the early 1990's there has been a marked push towards facilitating collaboration between the fishing industry and scientists in the fishery management process (Payne et al. 2008). The term "sentinel" was coined to take account of the long term monitoring role the use of commercial gear has had for each fishery, not unlike the role of a watchman or guardian. Sentinel Surveys or Fisheries act as indicators for the rest of the stock and allow for close-to-real time management of fisheries.

Sentinel fisheries represent a collaborative approach to fisheries science and management, and have been shown to forge mutual trust amongst stake holder in the information collected by the fishing industry, the science, and the resulting management advice (Parsons et al, 2008). Sentinel fisheries are cooperative research at its best, and represent the first step towards co-management where fishermen, scientists and managers share the responsibilities and benefits of fisheries management.

## Industry collaboration and scallop

Industry collaboration has contributed to scallop fishery management and examples in Australia and the US are well documented. Management of the Bass Strait scallop fishery off Tasmania is enhanced by industry-generated data, which is collected during fishing industry organised and executed surveys.

This example of industry-led surveying and collaborative management has been considered a major success and more data were collected at a higher frequency, spatial resolution and extent than dedicated research survey programmes, and at a reduced financial cost.

Financial incentives for fishers to participate were necessary, especially when surveys were needed in areas which are otherwise uneconomic for commercial operations. Incentives included options such as enhanced catching opportunities. Clearly defined survey aims and reasonable time requirements for sampling were considered key to continued fisher co-operation. Information from the fishing surveys were used to target additional survey resources, and to help define the in-year management decisions as well as redefining a more appropriate (lower in this case) Minimum Landing Size (MLS).

## Current Context

The scallop industry has been involved in dialogue with the government body Defra (Department for the Environment, Food and Rural Affairs) about the needs for stock assessment of the Channel Scallop fisheries. The Channel Scallop Fishery (CSF) has also been involved in wider stakeholder discussions about management of the stock in terms of fishery access and ownership. Both these processes – whether a stock assessment or ongoing management – would benefit from the collaboration of the fishermen involved in the fishery, enlisting their help with an ongoing survey effort.

Biological sampling of the CSF and other scallop stocks in English waters is currently being developed. One proposal is to undertake scientific surveys once every three years, and would be administered by Cefas (Centre for Environment, Fishery and Aquaculture Science). This program would have limited coverage in space and particularly time and could therefore greatly benefit from the wider coverage possible from a Sentinel Program. A regular, industry-led survey would provide the data required to fills gaps and improve management – increasing access to the fishery in the long-term and reducing risks for the supply-chain. This would encourage more suppliers to source from the fishery and lead to improved consumer confidence in the fishery itself.

## Key considerations

- Sentinel surveys can contribute to understand of stocks. E.g. the Penobscot ground-fish fishery in Maine, where the issue of localised depletion of stocks as illustrated by the sentinel survey is providing evidence that is central to the region-wide scientific and policy debate over ground-fish science and management. This improves assessment of the stocks and has become critical in mapping the recovery of stocks and the setting of future management plans. Participation of fishers in sentinel surveys increases trust and the accuracy of data series.
- Sentinel fisheries provide an ongoing and continuous record of otherwise data-poor fisheries, and can reduce uncertainty for managers.
- Sentinel fisheries become part of the overall leadership and engagement of fishermen; they need appropriate compensation to incentivise participation and the enrolment of fishermen as technicians/scientists.

- Co-management & co-design ensure that fishermen are actively involved in monitoring catches to facilitate management. This approach delivers meaningful engagement beyond standard consultative styles.
- Co-design establishes collective learning among fishermen, scientists, and managers to achieve a common understanding of our fisheries, marine environment, economics, and communities. This engages fishermen's creative problem-solving skills and redistributes responsibility for success. Shared understanding = shared responsibility.
- Sentinel fisheries close gaps between scientists and harvesters.
- Arguments may exist between sentinel and non-sentinel harvesters – the latter contesting the findings of the surveys. But this is because the protocol involved in 'fishing for science' is quite deliberately different to that employed when commercial fishing.

## Conclusions / Recommendations

Fishing into the Future has been funded to conduct a co-design process in collaboration with the CSF to devise a sentinel survey/fishery that meets the needs of fishermen, science and management. We would like to discuss the potential and options for this process with the South West Fish Producers' Organisation and its Scallop Group at an appropriate opportunity in the near future. We anticipate that this would involve providing a presentation on the issues as part of one of the SWFPO's regular scallop meetings.

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# APPENDIX 1. Industry Workshop 19th July 2016

# WORKSHOP REPORT

July 19th 2016 – Brixham Trawler Agents, Brixham Harbour, Devon

FITF is Supported by:

# 1. Meeting Summary

## Purpose

Fishing into the Future is working with Cefas to define an industry-based scallop survey for the Channel Scallop Fishery. Our partnership has the intention of securing detailed input into the survey design process from the fishermen involved, and to also secure their support for the survey as a whole. This will involve working with them directly through a number of issues, and this first workshop was aimed at gathering initial intelligence in order to inform the pilot survey design, with these pilots due for initiation in the summer of 2016.

There will be follow-up sessions to review the outcomes from the pilot surveys in order to inform and finalise the full industry survey, which will start in 2017.

## Headline Recommendations, Comments and Actions

### 1. *Diary for skippers*

It was recommended that the project team (Cefas) generate a diary proforma for scallop fleet skippers to complete as a means of collecting information that has the potential to inform the content and parameters of the scallop survey protocols. Cefas will develop this proforma and instigate an editing process with SWFPO before circulating hard copies to the fleet skippers.

**ACTION: Cefas to develop proforma and instigate editing process with SWFPO and circulate hard copies**

### 2. *Issues affecting catchability for consideration within survey protocol design:*

| Issue | Rank | Votes | Related issues and actions arising |
|---|---|---|---|
| **Weather** | 1 | 9 | • Science needs to identify the type of boats that they wish to use<br>• Once they know who is going to be involved, this helps define the parameters for the weather<br>• There is a need to speak to skippers whether we need more research into this |
| **Tides** | 2 | 7 | • Protocols can define tides better than weather<br>• Establish a diary system soon to assess factors that affect catchability [see recommendation 1] |
| **Location** | 3 | 6 | • The issue of the Median Line needs to be addressed but the intention is for the pilot survey to take place north of this line. |
| **Ground** | 3 | 6 | • Funding time is needed for people to iron this out<br>• It might be possible – and will be important - to build up a 'proxy' for stock measures based on information from beam trawls in support of the wider stock assessment |

| | | | |
|---|---|---|---|
| **Gear** | 5 | 5 | • Make sure all gear used remains in good condition and therefore working well |
| **Knowledge** | 5 | 5 | • The interpretation of information and how this is acted on by skippers is critical to commercial success |
| **Skipper** | 7 | 3 | • provided the survey uses the same skippers throughout the survey their relative performances won't be an issue |
| **Season** | 7 | 3 | • Eastern Channel seasonality is easier to define this – because it is cyclic in nature – than the Western Channel |
| **Crew** | 9 | 2 | |
| **Stock** | 10 | 1 | • "Stock is Fragile but Stable"<br>• There are concerns in the industry that the 'journey' of the stock assessment must take account of where the fishery is now and avoid harsher management if possible |
| **Regulations** | 10 | 1 | |
| **Technology on board** | 10 | 1 | |
| **Other related issues (with no votes)** | | | |
| **Market** | | | |
| **Running Costs** | | | |
| **Interpretation** | | | |

**ACTION: Cefas to consider all suggested issues and parameters above and integrate these into the design of a Pilot Survey as far as is possible. These recommendations will be reviewed 'post pilot' in order ensure full inclusion during the full-scale survey.**

3. *From general discussion:*

1. An experimental approach is needed to explore and define how many tows are needed to build up a reliable picture of stock biomass per 'statistical rectangle'
2. The relationship between skippers and scientists is key
3. Allowing for a 50:50 split between skipper-selected and science-selected survey sites may have many benefits for the survey in the long-term [industry buy-in and support]
4. Analyse VMS data and topography data to help with survey design
5. Report back from this meeting to the Scallop Industry Collaboration Group (SICG) on the 16th August.

**ACTION: Cefas to explore and define tow issues (bullet 1) during the delivery of the pilot survey.**

**ACTION: Cefas to consider the selection of sites (bullet 3) as a priority for this survey.**

**ACTION: Cefas to report back to the SICG on the outcomes of the workshop.**

# 2. Meeting Background

## Issues

The Channel Scallop Fishery (CSF) is looking for an accurate, ongoing stock assessment to ensure management takes account of the current state of stocks at any one time. The co-design of a 'Sentinel Survey' could allow the scallop fishery to contribute invaluable data to the management process. Collaboration with the fishing industry at every stage of the programme will be key to its success.

## Background

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## Key considerations

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## Conclusions

Fishing into the Future has been funded to conduct a co-design process in collaboration with the CSF to devise a sentinel survey/fishery that meets the needs of fishermen, science and management. We would like to discuss the potential and options for this process with the South Western Fish Producer Organisation Ltd and its Scallop Group at an appropriate opportunity in the near future. We anticipate that this would involve providing a presentation on the issues as part of one of the SWFPO's regular scallop meetings.

# 3. Meeting content: main discussion-points raised

## Catchability:

Two separate groups each considered the same question: *What issues will affect catchability that need to be considered in Survey Protocol Design?* The outcomes from these discussions were then combined in order to facilitate a discussion on ranking-importance. Votes were cast using a 'sticky-dot' system (otherwise known as 'dotmocracy'). The outputs from this session were as follows:

| Rank | Headline Issue | Related issues and information |
|---|---|---|
| 1 | Weather | • Different weather affects different sizes of boats, and on different grounds in different ways<br>• Max swell height for 10-15m vessel in Eastern Channel = 1m (0% gear efficiency) |
| 2 | Tides | • Direction of tow relative to tide<br>• Orientation of scallops relative to tide and direction of tow |
| 3 | Location | • Different locations require different approaches to fishing |
| 3 | Ground | • Topography |
| 5 | Gear | • Different locations require different gear set-ups<br>• Design<br>• Condition<br>• Sizes and regulations |
| 5 | Knowledge | • Interpretation of information by Skipper<br>• Historical knowledge of fishery and previous dredge tracks<br>• Contents of dredge |
| 7 | Skipper | • Speed selection<br>• Interpretation of knowledge<br>• Knowledge of stock and stock movements<br>• Fleet statistics and performance |
| 7 | Season | • What's happened before in the season – at that location |

| | | |
|---|---|---|
| | | • Time of year<br>• Movement of scallops relative to season |
| 9 | Crew | • |
| 10 | Stock | • Movements of stock<br>• Cyclic nature of stocks<br>• Scallop behaviour |
| 10 | Regulations | • Days at sea<br>• Compensation |
| 10 | Technology on board | • Machinery |
| - | Market | • Price of scallops<br>• Shelf-life<br>• Meat yield |
| - | Running Costs | • Shore-based support<br>• Polyvalence |

## Verbatim records

- Fishing gear can deteriorate quickly on rough ground and this needs to be considered in survey design – keep the gear fresh and new in order to maintain consistent performance.

### WEATHER

- Each boat has its own weather ‘model’ – the maximum swell lift it can accommodate
- Tides also affect this as well as tipping doors, making the gear hold the ground better
- There is a need to use the same boats throughout the life of the survey
- Need to choose boats that are scalloping regularly
- There would normally be a tendering process for this kind of research among the fleet
- Situation has changed and the industry is coming forward more to offer to participate in research efforts
- There is a need to know who would be willing or who is most appropriate to participate
- Might be better to approach the best vessels
- Science needs to identify the type of boats that they wish to use
- Speak to skippers about weather and whether we need more research into this
- Log books can provide data on prevailing conditions
- Once you know who is going to be involved, this helps define the parameters for the weather

## LOCATION – Median Line

- How is this going to be addressed?
- It is a shared stock
- The French do sample their own stocks
- Cefas remit is to assess ‘stocks of interest’ but would need permission from the French to survey their waters
- Does this apply even outside their 12nm limit?
- Not clear if we need permission inside the French side of the median line – but would require a dispensation
- Need to look at all stocks in all areas regardless of the median line
- Pilot will take place within the median line for simplicity’s sake

## HOW?

- Boats will define their weather windows
- Need to define cut-off points from skipper knowledge and best estimations
- There will not be one-rule-fits-all – it will be boat specific
- Possibly analyse logbooks and diaries for information to help with this
- Can we develop a weather diary to test assumptions?
- Helpful to have on-board transfer of data on the internet – this is now being used all the time to share pictures and thoughts
- Internet will play an important role in information transfer into the future
- Will surveys be separate from days at sea allocation?
- This is likely – but needs to be clarified
- It is a ‘big ceiling’ and it is down to the authorities to sort this out
- In principle it would not come off allocation of time / effort to boats

## TIDES

- Need to standardise and target median range of tides
- Tidal cycle during the day is also a factor
- This also relates to ground
- Could only sample during set points of the tidal cycle or fish throughout the tide and adjust figures accordingly
- Long-time series of data negates this issue
- Some areas don’t have slack water – e.g. Channel Islands
- Season may be more important than tides – scallops are mobile and yields changes
- Meat yield can change by +/-0 .5% over a short period and this has a massive impact on fish behaviour and value
- Scallop behaviour and catchability changes during its spawning cycle and is reflected in meat yields

- When scallop shoot their roe, this reduces catchability and commercial viability. They become “flighty”.
- French seasons are geared to when scallops shoot their roes
- Usually find it fishes better in a ‘making’ tide [heading towards springs]
- Need to pilot tows in different parts of tides to check this out
- Record information accurately during the pilot phase
- How long will boats be waiting on standby for the weather parameters to be OK?
- The closer we can define boats and parameters the better for all concerned
- This might affect incentives for skippers to participate in the survey
- How reliably can we predict the impacts of tides and weather?
- Long data sets will help with this
- Protocols can define tides better than weather
- Diary gives more data to work from
- Try to assess factors from diary data to see if these have been helpful
- We could get the diaries on the go tonight if we wanted?
- We need to define the information we would need to collect

## SEASONALITY

- Is it feasible to define what part of the season to use and does this change in different parts of the Channel?
- Eastern Channel is easier to define this – because it is cyclic in nature
- Western Channel is not so easy as you get two seasons
- Fishing is best between December – April [January – April]
- There is an issue with windfarms [Rampion windfarm] and the impacts of these on scallop stocks and fisheries

## LOCATION AND GROUND

- Can you get catchability from logbook data?
- There is huge variability in this
- Need lots of fishing to get to the bottom of this variability
- Fishermen know the ground that comes back quickly – there is a lot to consider
- You can’t assign efficiency to ground type due to changes in other parameters
- “Stock is Fragile but Stable”
- There has been no progress in gear technology, have been using the Newhaven Dredge for decades
- There are concerns that the ‘journey’ of the stock assessment must take account of where the fishery is now and avoid harsher management if possible
- There are unintended consequences from better information from the point of view of fishermen

- The survey aims to reduce uncertainty for management and refine confidence bands for management
- How confident are we in the efficiency of the dredge?
- Scallop stocks cover a huge area
- Offshore fisheries are very mobile and the inefficiencies of the dredge saves the stock from being over fished because this is simply not possible
- Vital people contribute to building the model being used for management
- Industry has to accept variability in stock levels and management requirements
- We need to nail down the probable knowns as soon as possible to make the survey as accurate as possible
- We need to know what the known errors are
- Can we monitor what the beamers are catching?
- Funding time for people to iron this out is needed
- You are never going to see immature fish from beamers at market but you might able to build up a picture of or 'proxy' for stock measures based on this information from beam trawls and this helps to identify further areas for any dredge survey
- Hundreds of tows are needed for a statistical rectangle
- 4 tows give you a picture of stock but not an accurate one or complete picture by any means and wouldn't give you a biomass assessment
- Let's experiment to see how many samples we need per rectangle – analyse variability – decide any levels of uncertainty
- For the dredge survey, do we want an experiment that defines protocols that adequately describe a rectangle?
- You need to sample all areas for a stock
- More samples = more accurate picture
- Pick an areas and keep a simple until the stock density estimates stabilise
- Account for seabed type and topography
- Fishing activity re-distributes a stock by disturbing them and scattering them
- Nail down inaccuracies within an acceptable level of uncertainty (e.g. 20%) and does this scale up or down for different sizes and types of boat?
- Marine Scotland may have already done some of this work – but this will have been on very different ground with different boats and only to show trends in stock density
- How do you allocate sample grids/tows?

## GENERAL DISCUSSION

- The relationship between skippers and scientists is key
- Can we build a picture from VMS data and known maps of fisheries?
- 50% selection of tows by fishermen / 50% of tows randomly selected by scientists [science vs instinct]

- If surveys aren't complete then this undermines the industry because it might underestimate the stock size
- New areas represent difficulties because fishermen don't know how to fish them 'well'
- Fishing known areas and efficiencies contributes to certainties of stock assessment
- The unknown areas may be more important to sample for the overall stock assessment
- VMS allows a desk-top study of hotspots to allow for defining survey areas
- Account for year-on-year rotation and fluctuations
- If we account for all these issues we might not have to do a pilot as such
- We need a parallel thread of monitoring catches from non-scalloping boats
- There needs to be feedback from this meeting [to the SICG] on the 16th August

## **Appendix I:** Detailed Agenda:

| **Description** | **Timing** | **Activity** |
|---|---|---|
| Welcome and introductions | 09:30 | Setting out aims and activities in the workshop – orienting participants to the process and timetable |
| Draft Survey Protocol Aims | 09:45 | Cefas sets the intentions for the long-term survey plan, introduces the pilot surveys as means to quantify key parameters affecting catchability. |
| Brainstorm | 10:00 | Groups brainstorm the question: "Which factors do you think will most affect catchability for the scallop survey?" |
| Consolidate/snowball | 10:05 | Group the ideas from brainstorm and start to think about ranking |
| Break | 10:55 | |
| Sampling exercise | 11:00 | Quick exercise in why we random sample |
| Interrogate methods | 11:15 | Use How/How/Where/When matrix to discuss survey issues and content |
| Industry sampling and Summary | 12:00 | Group discussion on industry sampling scheme; plenary discussion to explore main issues and outcomes from the session, to raise additional points and to clarify the next steps. |

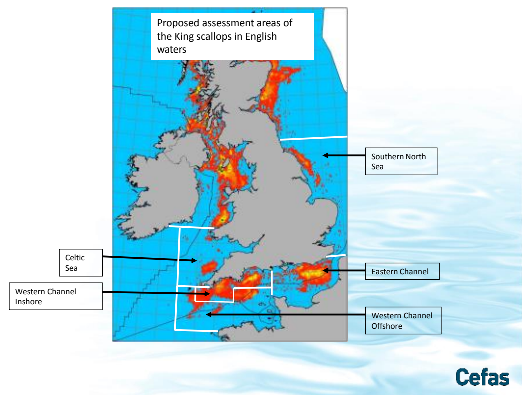
## **APPENDIX II** – Delegate List

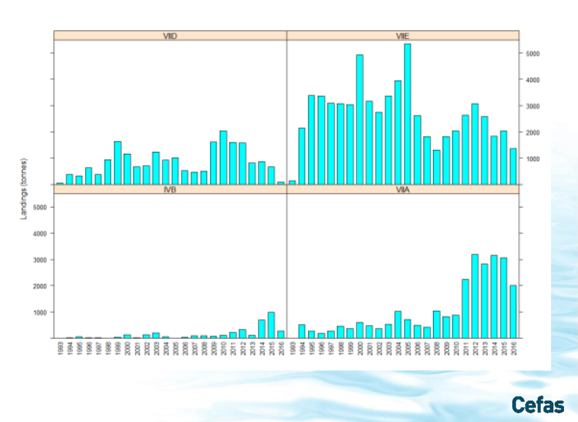
| Name | Organisation |
|---|---|
| Jim Portus | SWFPO CEO |
| Nick Prust | SWFPO CHAIRMAN |
| Ewen Bell | Cefas |
| Dave Palmer | Cefas |
| Andy Lawler | Cefas |
| Jim Masters | Fishing into the Future |
| Keith Schofield | Seafalke Shipping |
| Bill Brock | BNFS |
| Andy Scott | Macduff |
| Sarah Pilgrim-Morrison | Macduff |
| Sean Irvine | JFD Trawlers |
| Pete Mcleod | Mermaid |
| Mike Sharp | Emilia Jayne |
| Karen Pringle | SWFPO ACEO |
| | |

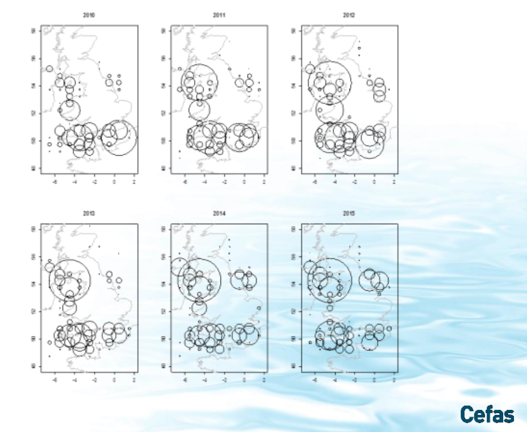
# APPENDIX 2. Scallop Seminar, Brixham. 11-Oct-2016

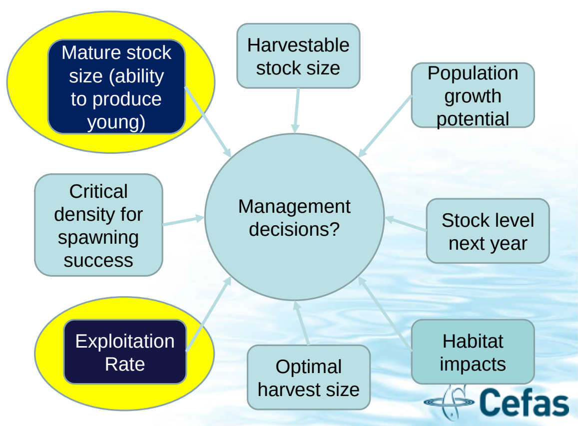
SWFPO convened a scallop seminar in Brixham, October 2016. The invited audience included industry members, IFCA representatives, invited experts (USA and France), UK academics and Cefas staff.

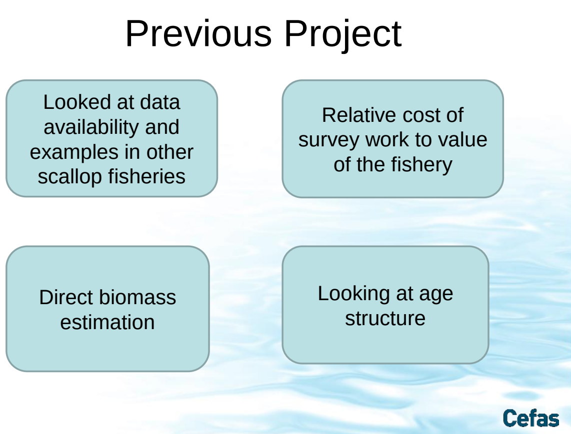
The following slides were presented to describe the work and general approach that is being taken as a result of the collaborative work with industry.

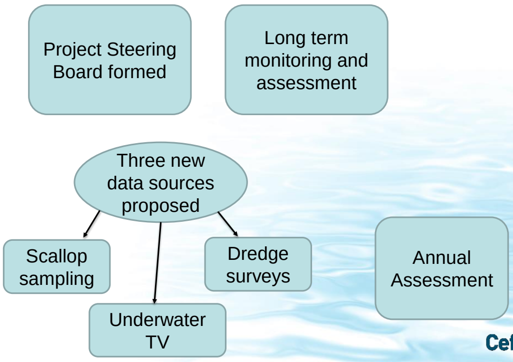



## The Plan

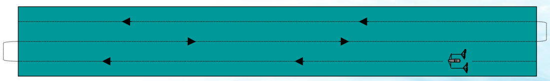


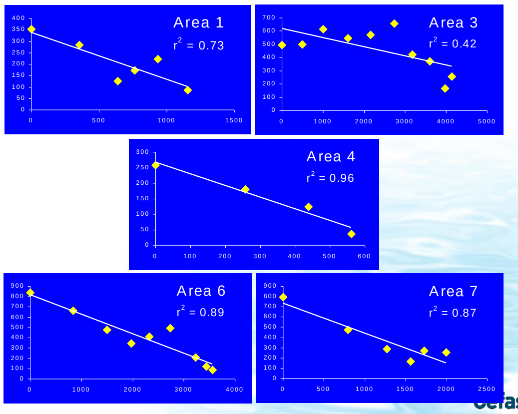

## Biomass estimation by dredge survey

- Catchability: The probability that a scallop within a defined area will be captured during a given amount of fishing effort.
- Patchy distribution of scallops

## Depletion Study

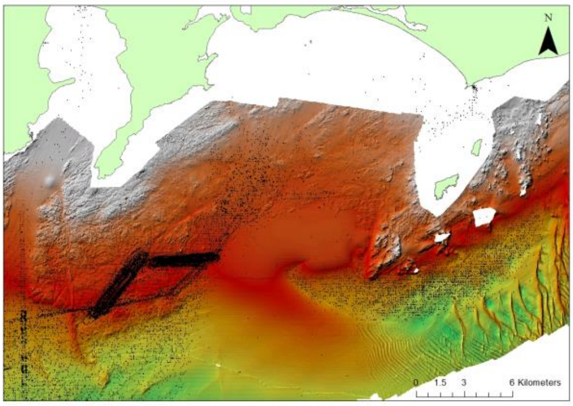
Plot size 1860m X 100m



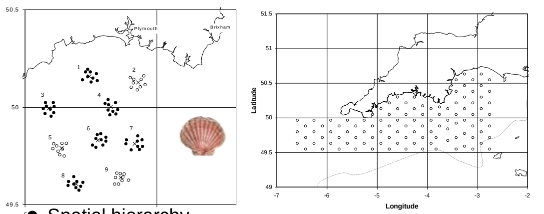



## Catchability

| Area | q | Substrate |
|---|---|---|
| 1 | 0.21 | Clean becoming stony |
| 3 | 0.07 | Rocks |
| 4 | 0.36 | Clean |
| 6 | 0.18 | Clean becoming stony |
| 7 | 0.27 | Flint cobbles |

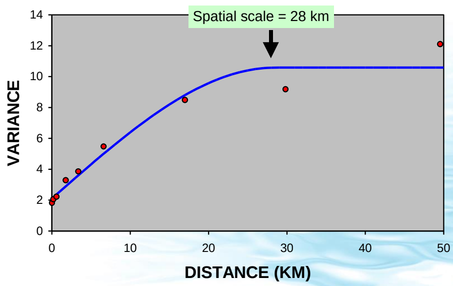


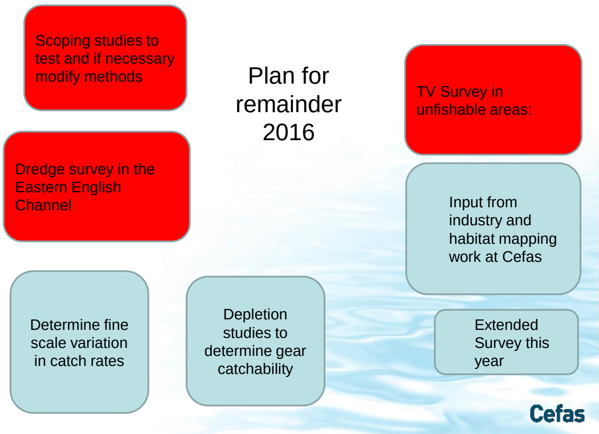

## Spatial and sampling variation

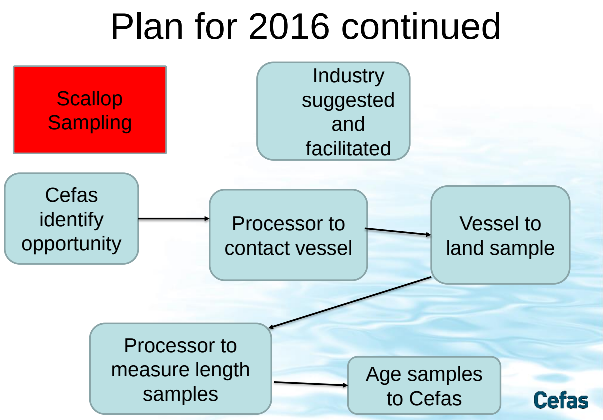



- Spatial hierarchy
- Replicate tows
- Catch rate, age and size of scallops
- Sediment

## Spatial scale of variation in catch rates - small scale




Scoping studies to test and if necessary modify methods
Plan for remainder 2016
TV Survey in unfishable areas:
Dredge survey in the Eastern English Channel
Input from industry and habitat mapping work at Cefas
Determine fine scale variation in catch rates
Depletion studies to determine gear catchability
Extended Survey this year
Cefas


Plan for 2016 continued
Scallop Sampling
Industry suggested and facilitated
Cefas identify opportunity
Processor to contact vessel
Vessel to land sample
Processor to measure length samples
Age samples to Cefas
Cefas

## Plan for 2017

Dredge survey in the English Channel

- Commercial FV
  - Standard gear and modified for pre recruits
- Stratified random design?

Scallop sampling scheme

First stock assessment Making best use of available data

## Subsequent years

More of the same, plan could evolve in response to lessons learned and to match resources

Role out methodology in other assessment areas?

Presentation to PSB, Industry and ICESWG as required

## *Pecten maximus* at home.

# APPENDIX 3. Industry Workshop 2 Mar 2017

# WORKSHOP REPORT

2nd March 2017 - King Scallop Stock Assessment in English Waters

Industry Workshop, Brixham Trawler Agent, Brixham Harbour, Devon

FITF is Supported by:

# Attendees

| Name | Organisation |
| --- | --- |
| Jim Portus | SWFPO CEO |
| Nick Prust | SWFPO CHAIRMAN |
| Ewen Bell | Cefas |
| Dave Palmer | Cefas |
| Andy Lawler | Cefas |
| Jim Masters | Fishing into the Future |
| Keith Schofield | Seafalke Shipping Ltd |
| Bill Brock | BNFS SWFPO |
| Andy Scott | Macduff |
| Sarah Pilgrim-Morrison | Macduff |
| Sean Irvine | JFD Trawlers |
| Pete Mcleod | Mermaid |
| Mike Sharp | Emilia Jayne |
| Karen Pringle | SWFPO ACEO |
| Neil Watson | |
| Will Naus | MacDuff Shellfish Ltd |
| Juliette Hatchman | MacDuff Shellfish Ltd |
| Andy Lawler | Cefas |
| Ewen Bell | Cefas |

# Workshop Agenda

1. Update of WS 1
2. Present results of scoping study
3. Outline plan:
    a. Vessel selection and ratification of survey plan by PSB 16$^{th}$ March.
    b. Survey Western English Channel May (approx. 10 days)
    c. Survey Eastern English Channel Sep (approx. 3 days)
    d. Biological sampling (industry facilitated sampling scheme)
    e. Stock assessment before end of year
4. Ewen to present random sampling demo?
5. Survey design **fisher contributions – split into groups?**
    a. Experimental gear for pre-recruits – **Gear selection what factors influence it**
    b. **Strata selection:** fishing intensity VMS? Scallop catches? Bathymetry? Substrate? Predefined uniform areas? Other? SEE VMS plots
6. Any factors the scientists have not yet considered?

# Meeting Summary

The second fishing industry workshop sponsored by Fishing into the Future was held at Brixham Trawler Agents 2nd March 2017.

The primary aim of the workshop (WS) was to present results of the dredge scoping study carried out in November 2016, following survey design and input at the first workshop. Following this to progress the plan for the forthcoming dredge survey in the Western English Channel scheduled in May.

For context Andy Lawler (AL) gave a brief outline of the main outcomes from the first industry WS and mentioned subsequent progress including the formation of the Project Steering Board (PSB) to oversee delivery of the project. An outline of progress and the plan for the next year was discussed. Vessel selection for the dredge scoping study was carried out by the PSB following a request for quotation was advertised on the government procurement site “Contracts Finder” in September 2016.

The FV Sylvia Bowers was approved for the scoping study work as she fitted all the selection criteria.

The workshop participants were informed that Defra and Industry money was funding the first year of work and EMFF had been confirmed by the MMO with Defra matched funding for the FY 2017/18. AL reported that the industry facilitated sampling scheme had started earlier in the year and the programme would become more comprehensive as more vessel enlisted in the scheme.

Underwater TV is planned in unfishable areas following some additional scoping trials designed to maximise the utility of this survey. The scoping includes aquaria studies to determine the response of scallops to light and sound stimuli like those presented by an underwater camera system and some field work to compare different camera deployment platforms. It is considered likely that scallop which are naturally feeding (open) are more visible than those that have closed in response to a towed camera system.

The first full survey will take place in the Western English Channel in May and it has been renamed from ‘sentinel’ to ‘pilot’ survey. Approximately ten fishing days will be required this area. A second survey in the Eastern English Channel of approximately three fishing days has been scheduled in September. The first stock assessment will be completed by the end of the year.

Results from the dredge scoping study suggest that fifteen-minute tow durations would provide adequate spatial coverage and maintain consistent fishing catchability for both high and low density areas typical for this area.

Geostatistical analysis of scallop density data taken over a grid of tows suggests that a sampling intensity providing a mean tow separation of between 15-20km would provide robust results and an efficient survey design.

Catch rates from paired stations carried out next to each other suggest that repeatability of results in generally good and that survey time otherwise spent on tow replication would be better used at other locations.

Two depletion studies where replicate tows were carried out over the same track did not deplete the abundance and provide estimates of gear catchability and an improved or alternative methodology would be needed. Gear catchability is needed to convert survey catch rates to abundance/biomass and must be estimated on another occasion.

Modified gear (experimental) deploying queenie bellies and thirteen-teeth toothbars on standard frames were fished alongside the commercial gear. They retained a smaller year class of scallop than the commercial gear but filled with dead queenie shells and stopped fishing even over short tow durations.

During the presentation of progress, plan and dredge scoping survey results there was some interaction with the industry throughout. There were industry concerns that scientists were measuring scallop height rather than the width, the metric used for scallop landing size enforcement. Scientist agreed to provide information on the relationship between the two-alternative metrics at the next PSB meeting.

# Interactive Session:

## Defining sampling areas/strata

Ewen Bell presented information explaining potential sampling strategies.

This was followed by an interactive session where the industry was asked to assist scientists in defining appropriate sampling strata for the pilot survey scheduled for May.

Fishing activity in the form of the last three years of VMS positional data for scallop dredgers was presented on paper charts and the industry were invited to annotate the charts to highlight areas which needed to be considered as separate assessment areas (to be treated as separate strata).

They were asked what defined boundaries observed by the VMS data and explain structure in the data which was not evident to the scientists. These included the patterns of lines observed in the VMS data in ICES rectangles 28E4. Fishers suggested that skippers in this area tend to tow in troughs between banks of dead shell where there are no scallops.

They suggested that to ensure sampling high and low density areas in the areas that tows across the ridges/troughs might be appropriate, a view shared by the scientists. Other features in the observed VMS data were explained by the fishers.

At the end of this exercise the scientists were better informed and will be able to translate this information into a survey design for ratification by the PSB in Edinburgh 16th March.

## Industry-led maps of assessment areas

Industry was asked to assist scientists in defining appropriate sampling strata for the pilot survey scheduled for May.

Fishing activity in the form of the last three years of VMS positional data for scallop dredgers was presented on paper charts and the industry were invited to annotate the charts to highlight areas which needed to be considered as separate assessment areas (to be treated as separate strata). This is shown figure 1 below.

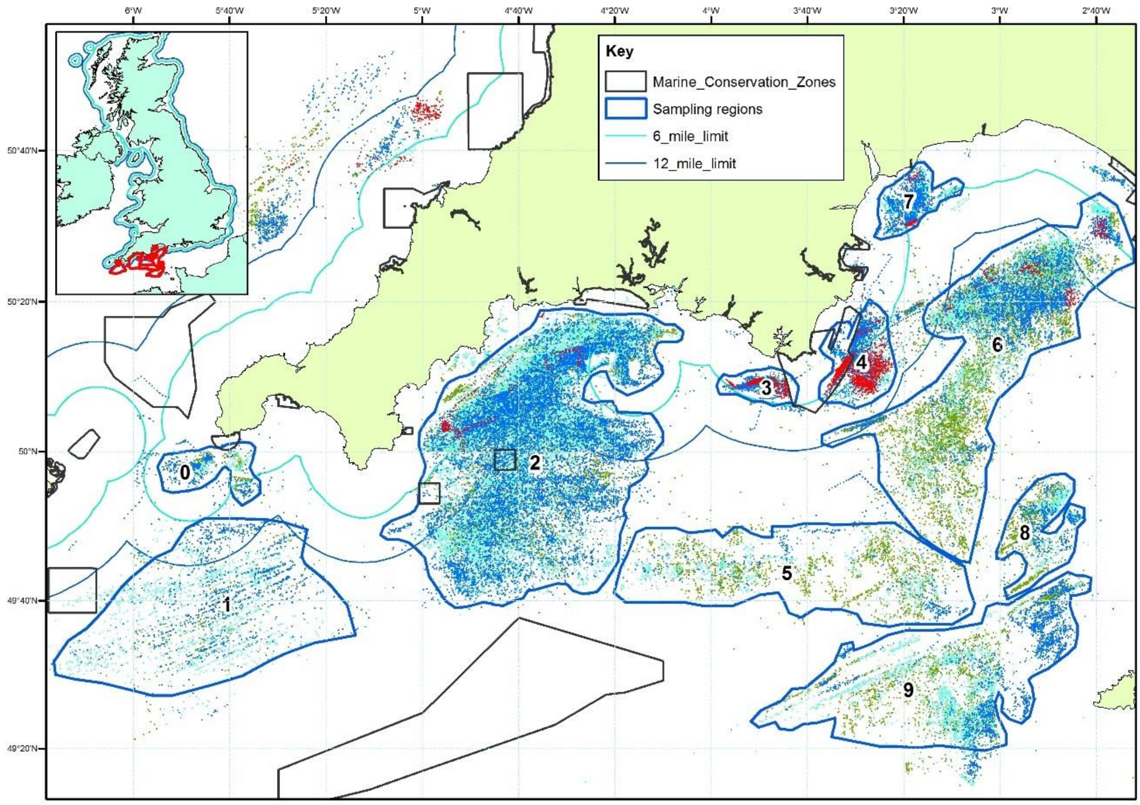



**Figure 1.** Industry led maps of scallop areas considered to be treated as separate assessment areas (Crown copyright, Cefas, 2017).

## Experimental gear

The industry was asked to suggest modifications to the experimental gear which enable it to fish cleaner alongside the commercial gear whilst still retaining the younger year classes of scallops. Longer end bags, larger ring size in the belly and fewer teeth on the tooth bars were suggested. Sean suggested that if they had dispensation they could trial alternative gear for the scientists.

# APPENDIX 4. D3.1: 'Co-Design process' plan.

## Scallop dredge survey scoping study proposal

## Scope

This document suggests a proposal for the scoping work to be carried out this year. The primary objective of the scoping is to provide information that will facilitate selection of an appropriate survey design for subsequent years.

Factors influencing scallop catchability and highlighted at the Brixham WS will be dealt with using fishermen's logbooks.

### Why?

The dredge survey will be used to derive three main indicators of the stock.

1. The biomass of scallop on the ground.
2. The difference in scallop abundance between years.
3. The age composition of the scallop stock.

Where we observe differences in the catch rates of survey tows (both within and between years), we want to be able to identify whether this is due to real differences in scallop abundances, or if other factors (weather, ground type, skipper, sampling strategy etc) are likely causes. Reducing these uncertainties will increase the accuracy of the assessments.

These factors were discussed at the Brixham meeting and some solutions (e.g. fisher log-book) were proposed by industry. Some aspects remain, and we therefore propose to undertake some experimental survey work this year before producing the full survey plan for 2017.

## Suggested aims:

1. Determine optimum tow duration for both commercial gear and scientific gear
   a. Survey time is limited; do we aim for a few long tows or many short tows? We certainly need to avoid gear saturation issues.
2. Investigate scallop distributions and appropriate sampling design (replication?)
   a. How close do we need survey points to adequately describe the local abundance?
3. Investigate the requirement of mark recapture experiment using a basic trial experiment.
   a. Understanding potential movement ranges will be key in designing station layout – how best can we mark scallops to monitor their movement.

### The Plan

- **Intensive fishing with variable tow duration** using both **commercial and scientific** (pre recruit) **gear** in different fishing areas (ground type and scallop density) should provide information on appropriate tow time. The aim is to provide an adequate sample even in areas with low scallop density but not to fill the dredge with scallop or by catch which would prevent the dredge sampling effectively throughout the tow. We will determine the optimum tow duration for each gear type but in reality for the annual surveys a compromise tow duration is likely to be used so that commercial and scientific gear can be fished at the same time. A standard tow duration is likely to be used for the annual surveys unless problems with the dredges overfilling necessitates a shorter tow duration. As we will want to standardise tow speed, by fixing the tow duration we will be standardising the towing distance.
- **Intensive fishing over a grid of stations** in different fishing areas (ground type and scallop density) **with replication** (repeated towing over the same tow) will enable investigation of the patchiness of scallop distribution (to inform the and repeatability of the results. A suitable experimental design could enable these first two aims to be investigated at the same time.
- **Mark recapture experiments** are often used by biologists to look at both population size and individual movements. They could be particularly useful to the project in providing information about scallop dredge efficiency (when deployed over a short time) and also about scallop movements over a longer time period. The scale of any movements detected could have implications for stock definition and assessment. A full mark recapture experiment is beyond the scope of this project but a simple trial could test marking methods and determine the feasibility of using such techniques for assessing dredge efficiency. This work would dovetail with the intensive grid work suggested above, with repeat visits across the two

## When?

As soon as possible. Preferably before the Baie de Seine fishery opens and the weather deteriorates.

# Underwater TV - Proposal for an extended survey

## Scope

Financial limitations in subsequent years make a regular TV survey unlikely, at least as part of this project. Money is available this year (to March 2016) so we propose an extended TV survey more comprehensive than the originally proposed scoping study. The primary objectives of this work are to determine the distribution and abundance of scallops in unfishable areas and to determine the importance of underwater TV work in subsequent years.

## Why?

Fishing with scallop dredges is not possible throughout the distribution of the scallop populations due to fishing restrictions or unsuitable substrate. Scallops are known to exist in these areas and these should contribute to the spawning stock. To ensure that any stock assessment is as comprehensive as possible, the scallops within the unfishable areas should be included. Areas containing scallops which are unfished for commercial viability reasons but are on ground that can technically be fished with dredges should be sampled during the dredge surveys.

# Suggested aims:

1. Determine abundance and distribution of scallop in unfishable areas.
2. Determine utility of TV work for subsequent years.

## The Plan

We propose using underwater video cameras deployed using drop frames and operated from suitable vessels. Lasers and differential global positioning systems will be required to determine field of view and distance run so that a quantitative assessment of scallop density can be made at each site.

IFCA survey vessels are ideally suited to this kind of work in inshore waters, but larger vessels will be required to carry out the survey further offshore.

The use of towed sledges may provide better results in some areas.

## Where?

Cefas has some information on the distribution of exposed rock and boulder in the English Channel and Celtic Sea. Similarly, we have information on the distribution of scallop fishing effort and their proximity to Marine Protected Areas where scallop fishing is restricted. Cefas/Defra has extensive recent underwater TV coverage in many MPAs but these images were collected for a different purpose so their utility for scallop stock assessment are informative rather than a substitute for our requirements.

**We need input from the industry to highlight areas which are inaccessible to dredges but likely to contain scallops.**

The number of survey days and the location of the work will as always be financially restricted and dependent on the relative split between larger offshore or smaller and more economical inshore vessels.

## When?

This work needs to be carried out soon to avoid the expense of disruption caused by bad weather. It has to be carried out this FY.

# Scallop Sampling Scheme proposal

## Scope

- This is a draft proposal for the generation of biological data that will feed into scallop stock assessments for English waters.
- It gives suggested roles for the three sectors that are integral to the process, fishers, processors and science.
- This is very much a *draft* to start the discussions around how to make this work efficiently and reliably.

### Why?

The objective of the sampling scheme is to capture the age-profile of the scallop landings. The age profile of the landings can tell us how quickly a population is being depleted. When fishing rates are high, landings are likely to be dominated by young ages, whereas when fishing rates are at MSY levels landings should have a significant proportion of older scallops.

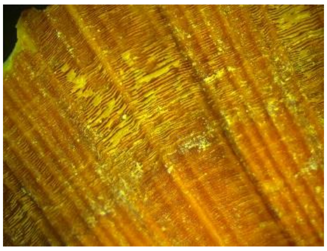
### Telling the age of scallops.

Scallops put down lots of tiny growth rings on the flat shell. When growth slows (such as in winter), these rings bunch together to form bands. Counting annual rings tells us the age of the animal, much like reading the age of trees. Shells in some areas can be read by eye, however in other areas we need to use microscopes. Winter is not the only cause of slower growth, shell damage can also affect growth. If a scallop hits the teeth of a dredge and is not selected, or is caught and then discarded again, although the animal is usually alive recovering from any shell damage will be the primary task and growth generally slows for a while. In areas of high fishing rate, the probability of shell damage becomes higher. Checking that winter growth rings are not damage checks is integral to the process.

Growth rates are area specific. Eastern channel scallops grow very quickly, particularly in the French areas. Western channel scallops tend to be slower, although again on the French side this is not the case. Inshore Cornwall scallops grow the most slowly. Even within these broad areas, there are significant differences in growth rates. Knowing exactly where the animals come from is therefore important.

Reading the age from marine animals (e.g. from scallop shells or fish otoliths) is relatively slow, taking an average of 2 minutes, whereas measuring the height of a scallop should take around 2 seconds! If a special scallop measuring board is used, it should be possible to measure a bag of ~140 scallops in 10 minutes (one person measuring, one person recording on paper).

By combining lots of length measurements with a carefully selected set of age measurements, we can provide a robust estimate of the age-composition of the landings. This is the standard process used in fin-fish stock assessments.

## The plan.

- 2-3 times a week Cefas identifies the vessels to be sampled that day based on their current position. Also decides the sample type (length=red bag or age=blue bag).
- Cefas gives the vessel list and sample type to the industry coordinators (SWFPO, and others).
- Coordinators contact the vessels.
- Vessels take the sample that day and put in the specified bag. Tell coordinator when sample taken.
- Processors receive the sample
    - If scallops came out of a <u>red</u> bag then processors measure sample and post the paper measuring sheet to Cefas.
    - If the scallops came out of a <u>blue</u> bag then processors send the flat shells to Cefas via *quayside services*.
- Cefas does the age-reading, inputs length measurement sheets and maintains database.

## Anticipated industry commitments.

- Coordinators.
    - 2-3 times per week receive contact list and contact vessel(s).
    - Number of vessels requested per day ~1-2
- Vessels.
    - 1-2 samples per month.
    - More vessels participating = fewer requests.
- Processors
    - ~3 samples measured per week
    - ~1 sample (blue bag) shipped to Cefas per week.

# Appendix 5. Sentinel survey report

# Scallop Dredge Scoping Study – King Scallop Stock Assessment in English Waters

*Andy Lawler, Robin Masefield, Karen Vanstaen*

Cefas report

# Executive summary

A project with the aim of determining stock status of the king scallop *Pecten maximus* in English waters relies on two new data streams. One of these is an industry facilitated scallop sampling scheme to provide the size and age structure of the catch. The other relies on abundance and biomass estimates from dredge and underwater TV surveys. Both these require some scoping to determine and solve technicalities and issues concerning data reliability and to enable a robust stock assessment. This report describes the scallop dredge scoping survey carried out in November 2016 in preparation for the pilot dredge surveys planned for the English Channel in 2017.

The primary aims of this scoping were to determine appropriate tow duration, examine the fine scale distribution of scallops in the Eastern English Channel, investigate the repeatability of the catches and trial a method for determining the efficiency of the gear. Secondary aims included trialling experimental dredges for sampling pre-recruits, testing radio transmitting calipers and collecting biological information for the Eastern English Channel.

Tow duration was varied in one study and the catches of scallops quantified from each tow. A fifteen-minute tow would be appropriate for this vessel as it provided an adequate and representative catch but did not appear to fill the dredges to the point where they stopped fishing consistently.

A grid of tows provided density estimates which were subjected to a geospatial analysis (kriging). A semivariogram from this analysis suggested a minimum sampling intensity of, on average, one tow every 15-20km would avoid under sampling. Sampling more intensely than every 15km would further improve the robustness of the results but on a law of diminishing returns (e.g. progressively smaller improvements with increased sample density).

Repeat parallel tows (paired tows) were carried throughout the survey grid, catch repeatability was shown to be good between most paired tows, but somewhat variable for several others. This was consistent with our expectations and typical of many fisheries surveys.

Two studies looking for depletion rates in areas of high and low scallop density were carried out by repeatedly passing over tow tracks. Unlike in other historic trials of this approach, no depletion was detected over the course of seven replicate tows. There are several hypotheses as to why no depletion was observed, but the overall implication is that this approach is not well suited to determining gear efficiency and a modified approach will be required for the future.

Four modified dredges with small belly rings (55mm ID), thirteen-teeth tooth bars and fine mesh backs captured a small quantity of smaller year class scallops but did not fish well and filled with dead queenie shells even over short tow durations. Further modifications suggested by the vessel skipper will be used on subsequent surveys.

Length distributions were collected from eighty-nine of the tows and size stratified samples retained for age determination.

# 1. Introduction

The project "King Scallop stock assessment in English waters" is a collaboration between the fishing industry, Defra and Cefas scientists and aims to determine the status of scallop stocks, first in the English Channel and subsequently in other fisheries in English waters. It is hoped that it will be the start of a long-term assessment programme that will provide information for fishery managers and the fishing industry. Both the industry and fishery managers require a scientifically robust assessment to inform the potential for management plans. The results need to be transparent and have credibility both in the scientific community as well as in the fishing industry.

The project relies on two new data sources; distribution and abundance estimates from dredge and underwater TV surveys and an industry facilitated biological sampling programme to provide the length and age structure of removals from the fishery. The dredge surveys will describe distribution and abundance of scallops in areas that are accessible to commercial fishing gear whilst the underwater TV surveys will provide information on scallop populations in areas that are not, but may still support populations of scallop.

Design of the dredge surveys requires additional information to overcome technicalities of operation and delivery, and before the information can be used for stock assessment purposes. To provide this some scoping work was required before execution of the first full survey in 2017. This report describes the results of a dredge scoping survey carried out in the Eastern English Channel on a commercial scallop dredger in November 2016.

# Objectives

**Primary objectives:**

1. To determine the optimum tow duration for the dredges
2. To determine the fine scale spatial distribution of scallop in an area of the Eastern English Channel.
3. To determine the repeatability of the catches.
4. To trial a method designed to determine the efficiency of the scallop dredges on different ground types in the Eastern English Channel.

**Secondary objectives:**

5. To take length samples of scallops to determine the size structure throughout the survey area.
6. To take samples for subsequent age determination.
7. To trial Bluetooth® callipers in the below deck environment.
8. To test the suitability of modified queenie dredges (experimental gear) for sampling pre-recruit king scallops.

## 2. Methods

# Vessel selection

A request for quotation for the charter work was advertised on the government procurement site Contracts-finder in September 2016 and in line with public service procurement rules (see Appendix 1). The owners of the FV "Sylvia Bowers" have a keen interest in the sustainability of the scallop stocks in English waters and offered a price for her hire. No other vessel owner provided a tender and the Sylvia Bowers was awarded the contract after it was clear she was a capable vessel and fulfilled all the vessel selection criteria. The vessel is a 413t 36m scallop dredger with a highly-experienced skipper and crew and a track record of fishing for scallop in the English Channel.

# Fishing Operations

Dredging operations were carried out across the tide (the standard procedure for this fishing vessel) but other factors like wind strength and direction, and sea bed topography, occasionally necessitated a tow direction at an alternative angle. Tow speed was approximately 3 knots but dependent on prevailing conditions. Warp out was set to 2 times the water depth plus an additional 18m. The standard compliment of gear for this vessel was thirty-four 0.75m Newhaven dredges fitted with eight-teeth tooth bars and 85mm internal diameter rings in each dredge belly. These were deployed seventeen dredges per side. Gear was maintained periodically to a suitable schedule and tooth bar spring tension was checked frequently and maintained at approximately 100Nm. At the end of each tow the dredges were emptied using a hydraulic lifting gate onto a conveyor system. The double conveyor moved the dredge contents below deck to facilitate manual removal of the catch from the debris which was discarded automatically overboard. Quantification of the catch of commercial and undersized scallops was by means of the vessels' motion compensated balance. The scoping survey plan is attached at appendix 2 and the trip report appendix 3.

## Determination of optimum tow duration

At each of two sites twelve stations were fished within an area approximately 5km wide. The two sites were located around a midpoint of 50 26'N and 00 02'W and 50 26'N and 00 20'W respectively and were approximately 20 km apart (fig. 3.4.1). At each site three tows were carried out at 10, 15, 20 and 30 minutes' duration. For tow numbers three to twenty-eight, six of the standard commercial dredges on the starboard beam were substituted with four experimental dredges allowing for a space between the experimental and standard gear. This enabled easy differentiation of the catch from experimental dredges and the standard gear. Catches were standardised to provide catches by dredge numbers and by dredge numbers and tow duration.

Analyses were carried out using R statistical package (R Core Team, 2016).

## Spatial distributions

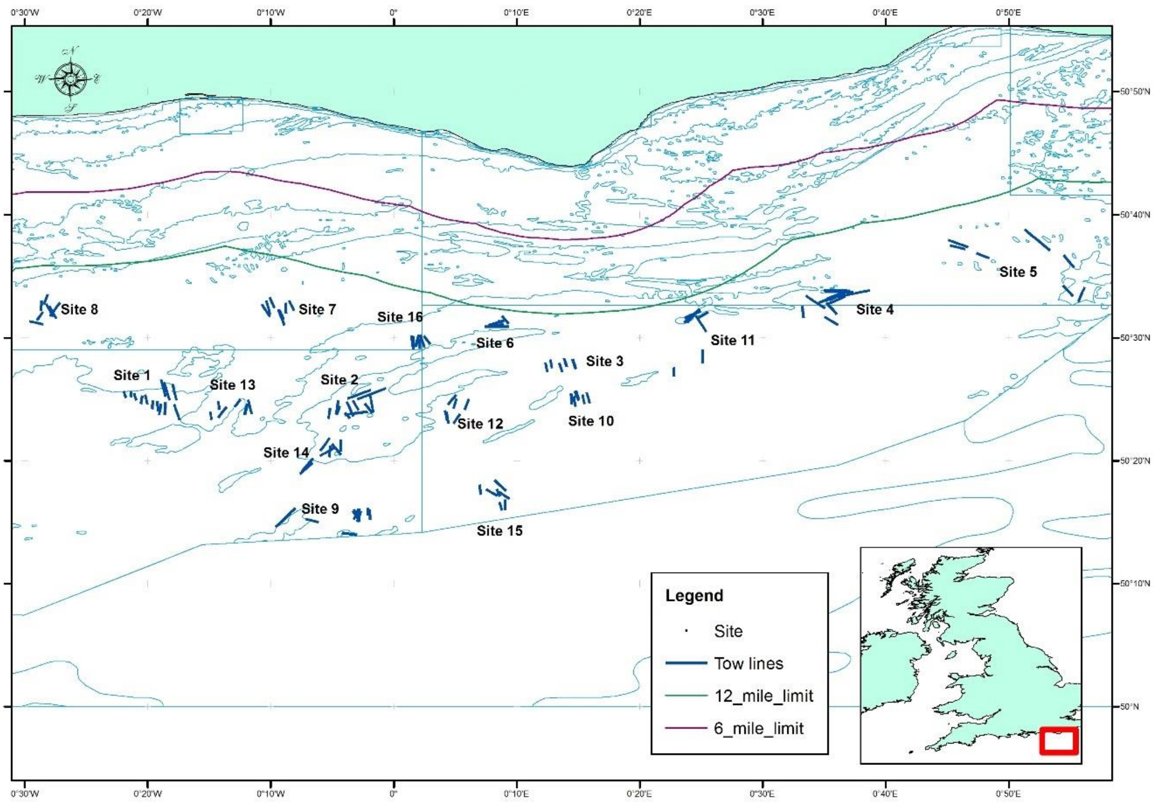



Figure 3.4.1 Tow start and end positions with assumed track

The skipper of the vessel was asked to select a grid of sites approximately 20km apart and at each site carry out seven twenty minute tows within a box approximately 5km wide. The survey was restricted to English waters to the north of the mid-line and outside the 12nm limit from the English coast. Aggregate dredge sites and other navigational issues were also avoided providing a grid of sites and clusters of tows which gave good spatial coverage but which was not symmetrical. Early completion of the original grid of tows enabled carrying out tows at additional sites and in between the original sites. Seven tows were carried out in each of fourteen sites (n=98).

Catches were converted to densities by dividing by the area swept computed from the product of distance run and dredge spread in metres (number of dredges x 0.75m) and where distance run was estimated from the start and end positions after assuming a straight-line tow.

Densities were subjected to geostatistical analysis using a kriging method to predict values between the tow positions. A semivariogram showing semivariance against distance between tows was produced to describe the spatial continuity of the data and using initial variables defined as:

Partial Sill = $gamma_{max}$ (maximum sample variogram distance), Model type = Exponential, Range = ($distance_{max}$)/2, Nugget = mean(gamma)/4.

The analyses were carried out using the packages gstat and spatstat (R Core Team, 2016).

A map of the scallop density (kg/$m^2$) was then produced using Kriging on a 500m square grid.

## Repeatability of catches

In each of the fourteen sites defined above and of the seven twenty minute tows carried out within, some were deliberately near and parallel to each other. At three sites two of the tows in each were near and parallel to each other and no more than a few hundred metres apart (paired tows). At Nine sites two paired tows were carried out. Direct comparison of catch rates between these paired tows was made. In addition, seven tows were carried out on the same track at each of two sites as part of the trial depletion studies giving an alternative indication of catch repeatability.

## Gear efficiency

Two depletion studies were carried out (site 4 and 9) after initial tows identified these areas as giving reasonable catch rates of scallops. The vessel carried out 7 twenty-minute tows on the same track at each of the two sites to deplete the scallop density over the course of the track. Catch rates from each tow were plotted against cumulative catch for each of the two experiments so that the slope of the fitted straight line is equal to the catchability (q) of the gear (Leslie method). Catchability can be described as the relationship between Catch per unit effort (in our case kg per 20-minute tow) and the population size. Gear efficiency can be described as the probability of a scallop in the path of the gear being captured. Gear efficiency (e) is related to q by the formula $e=q*A/a$, where A is the total area of the population under investigation and a is the area swept by the gear. In this study where we were towing over the same tow track A and a are equal so efficiency and catchability are the same.

## Length sampling

Sub samples of scallops were taken from the retained and discarded components of the catch for measuring. The shell height was measured as opposed to the length measurement used for Minimum Landing Size MLS because this parameter is usually less susceptible to bias caused by shell damage. Samples were weighed using the vessels' digital scales along with the total catch to enable raising by weight to the total catch per tow.

## Age sampling

Size stratified samples of 5 individuals in each 5mm size grouping were taken at 13 sites for subsequent shore based age determination. The age structure of the catch from this survey and their spatial distributions do not form part of this report and will be presented elsewhere.

## Bluetooth® calipers

Bluetooth® LE digital Vernier calipers (Sylvac, 200mm) paired with a Google Nexus 7 2013 android tablets were used to measure samples of scallops to capture size information directly into electronic format. The electronic files produced were copied onto an Asus notebook computer.

## Experimental gear for pre-recruit scallops

Four modified dredges were fished alongside 28 standard dredges for 25 tows at the first two sites. The specification included bellies with 55mm internal diameter rings fitted to standard Newhaven dredge frames and 45mm mesh backs. The dredges had thirteen-teeth tooth bars for the first 5 tows but these were substituted for standard eight-teeth tooth bars for the subsequent 20 tows. A qualitative assessment of the quantity of bulk in the dredges was made before tipping. Quantification of the scallop catch from both the experimental and commercial gear was carried out and a few size distributions of scallops taken in the experimental gear were plotted.

# 3. Results

## Determination of optimum tow duration

The distribution of catch rates observed during the tow duration study are presented by site as the first site (site 1) appeared to be a "low-density" area and the second site (site 2) exhibited higher catch rates (assumed high-density, figs. 4.1.1. and 4.1.2).

Mean standardised catch rates for the low-density site were 11.1, 9.0, 10.0 and 11.8kg per 10 minutes per 10 dredges for 10, 15, 20 and 30 minute tows respectively (fig. 4.1.1). Minimum standardised catch rates were 7.7, 6.1, 7.3 and 10.4kg/10min/10dredge and maximums were 16.9, 10.5, 13.4 and 13.7kg/10min/10dredge.

Mean standardised catch rates for the high-density site were 38.9, 38.6, 35.8, 24.1kg/10min/10dredges for 10, 15, 20 and 30 minute tows respectively (fig. 4.1.2). Minimum standardised catch rates were 34.1, 31.0, 22.2 and 22.6kg/10min/10dredge and maximums were 45.6, 47.6, 45.1 and 26.3kg/10min/10dredge.

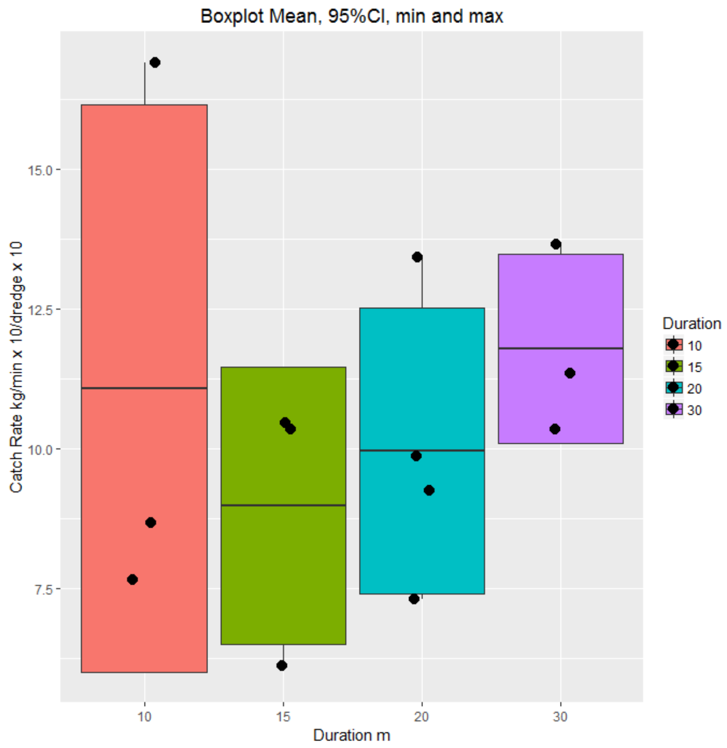



Figure 4.1.1 Catch rate of scallops in a low-density area standardised to 10 dredges per 10-minute tow for each tow duration

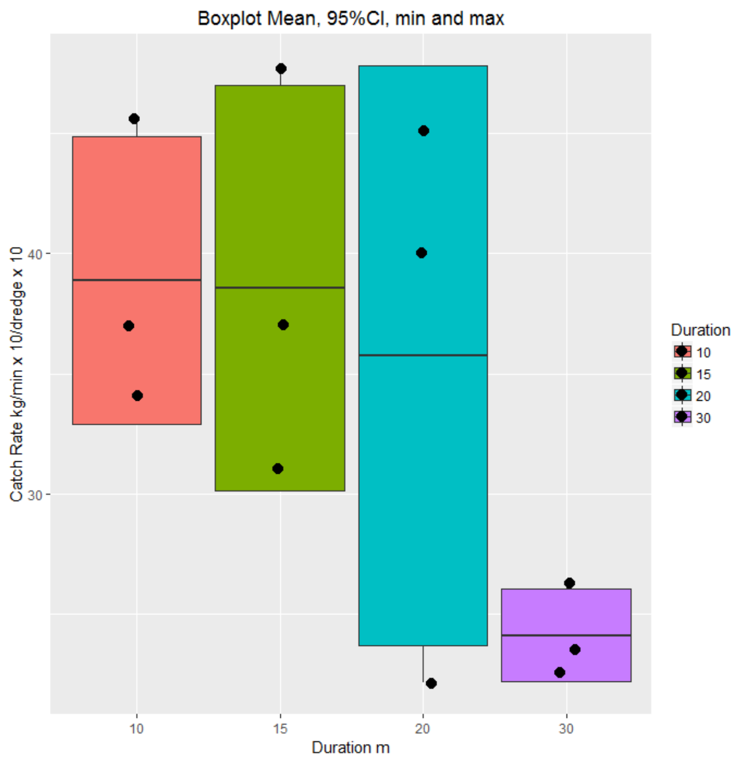



Figure 4.1.2 Catch rate of scallops in a high-density area standardised to 10 dredges per 10-minute tow for each tow duration

# Spatial distributions

The distribution of tow tracks shows a good spread of positions within the Eastern English Channel area outside 12 nautical miles from the English coast and inside the Channel midline (Restricted to English territorial waters, fig. 3.4.1). Catch rates were generally lowest at site 5 and highest at sites 2 and 9 and ranging from 2.8kg per 10 dredges per 10-minute tow to 53.6kg (fig. 4.2.1).

Scallop densities at each tow position are presented with the spatial boundary used for the spatial analysis (fig. 4.2.2). The density plot produced by the kriging technique shows the tow positions and highlights the high and low density areas and visualises the interpolated values between sampling positions (fig 4.2.3). A summary of tow details and catches is attached as appendix 5.

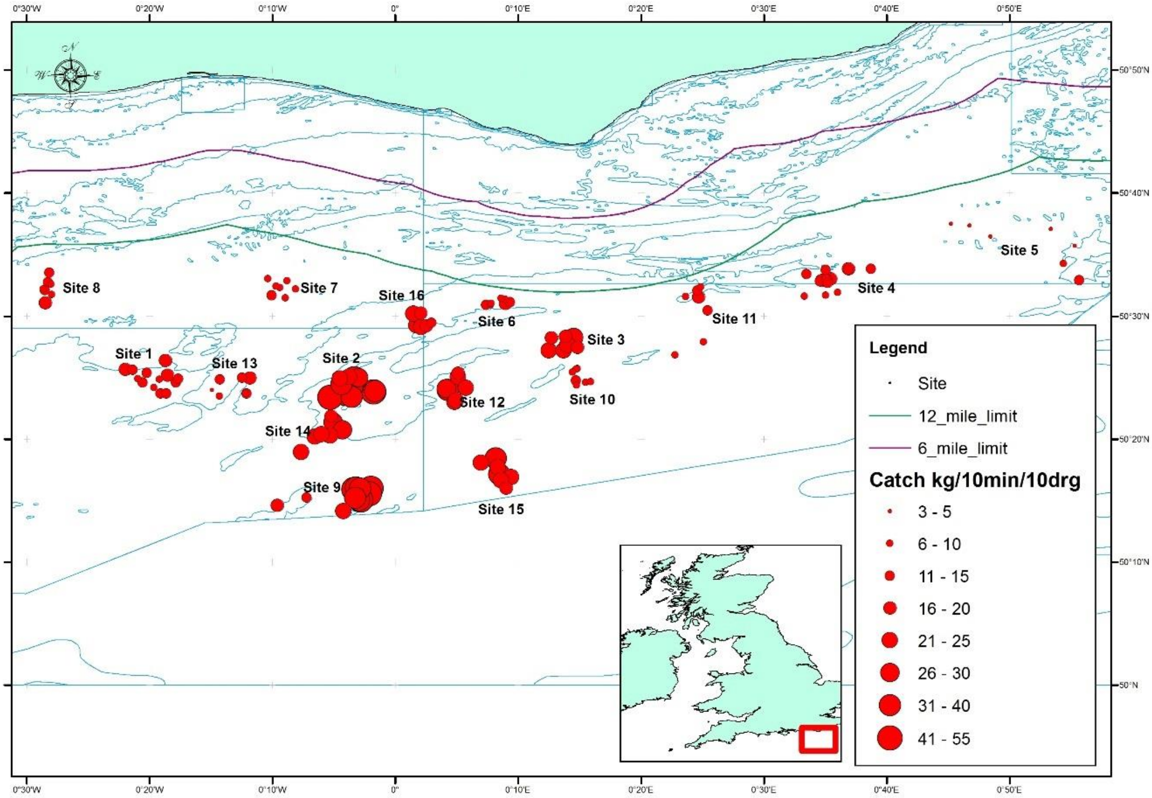



Figure 4.2.1 Distribution of scallop catch rates over the survey area

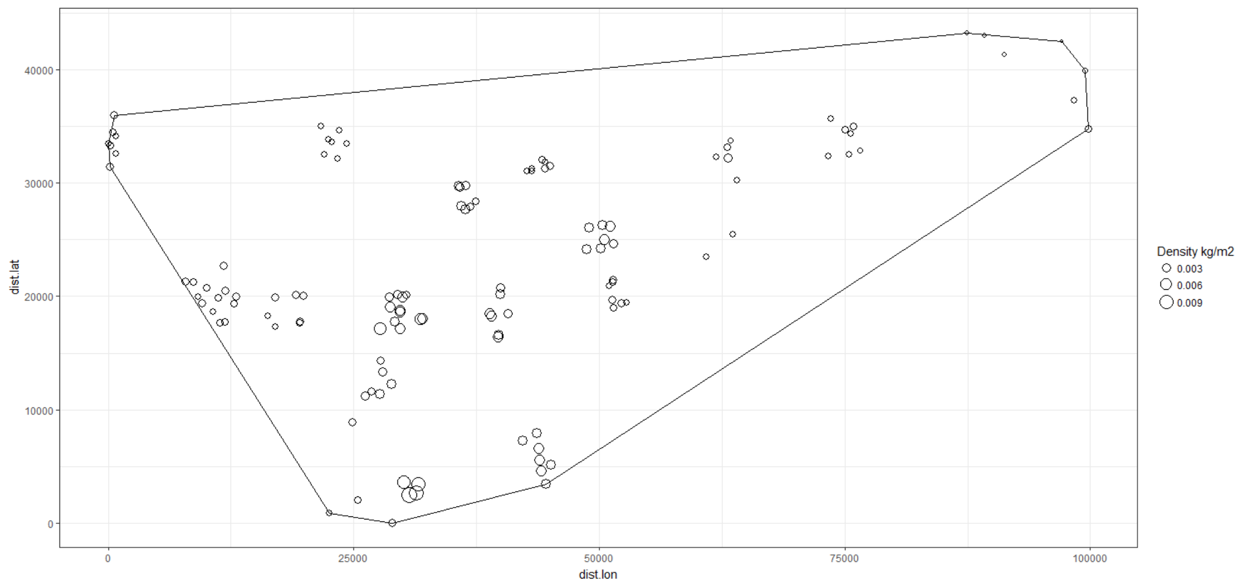



Figure 4.2.2 Distribution of scallop densities and the boundary drawn around the survey area for kriging purposes

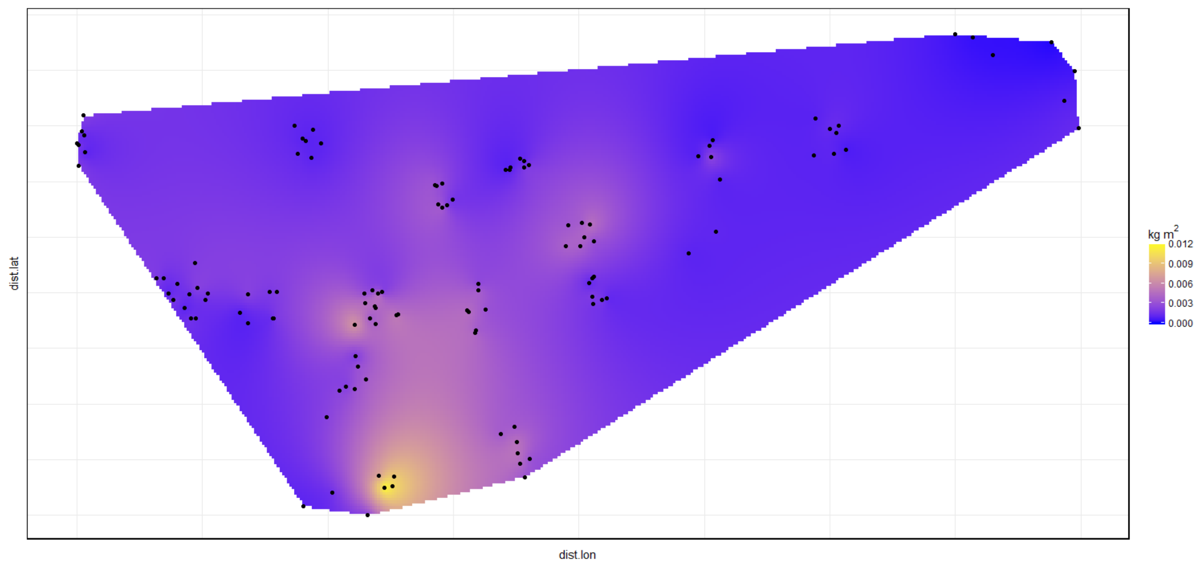



Figure 4.2.3 Tow positions and visualisation of predicted scallop densities after interpolation

The semivariogram produced by the kriging technique (fig. 4.2.4) shows that semivariance is variable at higher tow distances but the fitted curve starts to tend towards a plateau at tow distances more than 20km but is not well defined.

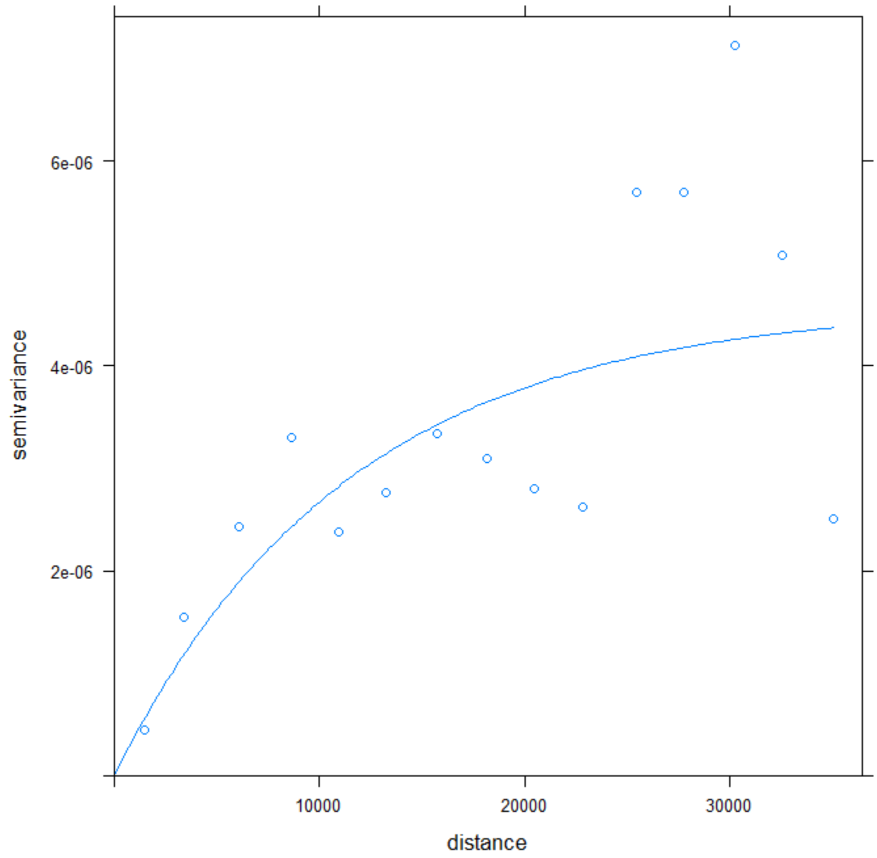



Figure 4.2.4 Semivariogram output from geostatistical analysis.

## Gear efficiency

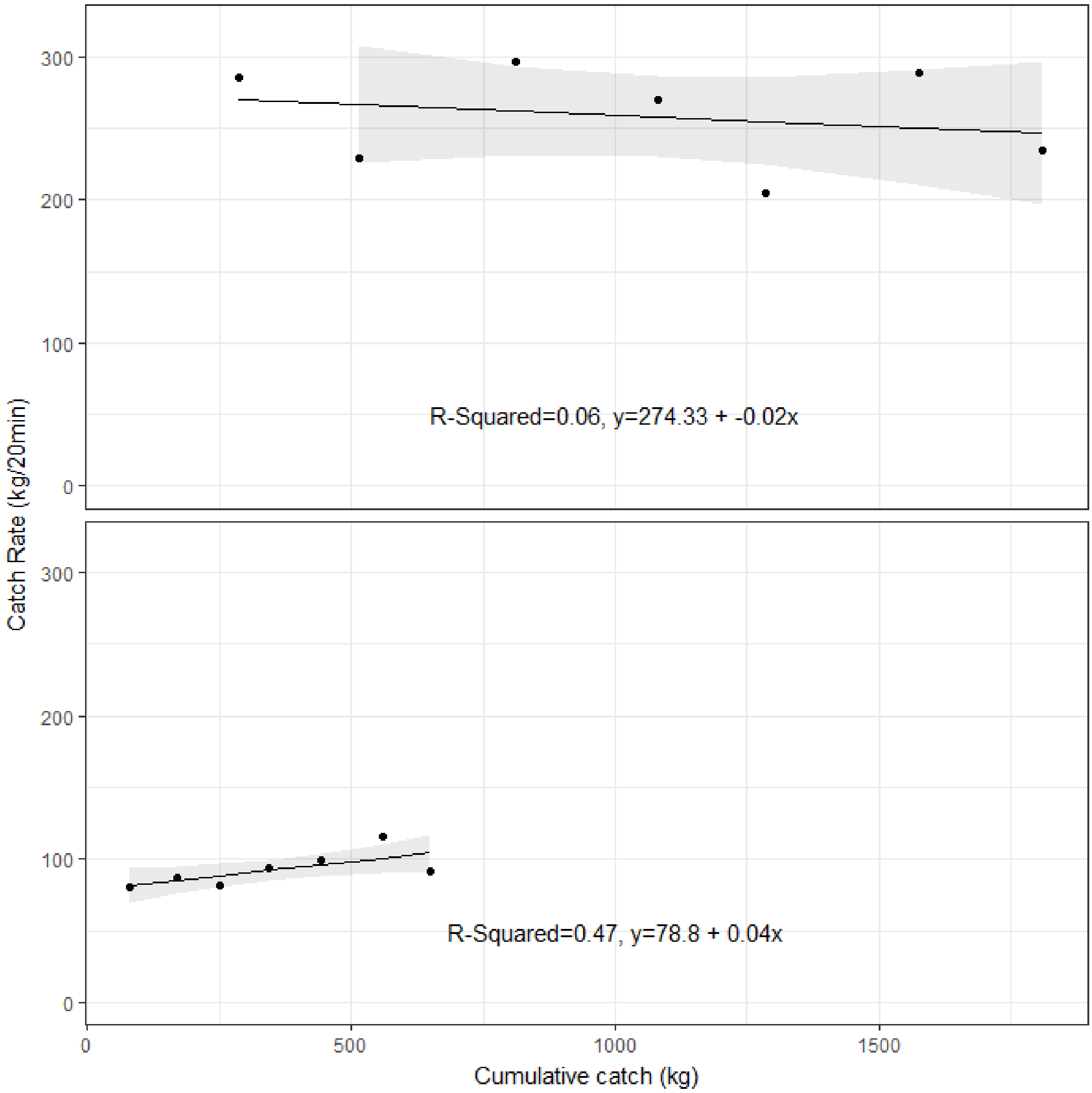



Figure 4.4.1 Results from two depletion experiments. The first experiment carried out at site 9 (top panel) and the second experiment carried out at site 4 (lower panel). Catch rate against cumulative catch.

During the first experiment catch rates ranged between 205 and 296kg per twenty-minute tow. The fitted line was not significantly different from zero showing no depletion occurred over the 7 tows. The second depletion experiment provided catch rates ranging from 80.9 to 115.4kg per twenty-minute tow. Although giving a higher correlation (0.47) than the first experiment, the fitted line provided a positive slope of 0.04 indicating that the catch rates increased as repeat tows were carried out.

## Length sampling

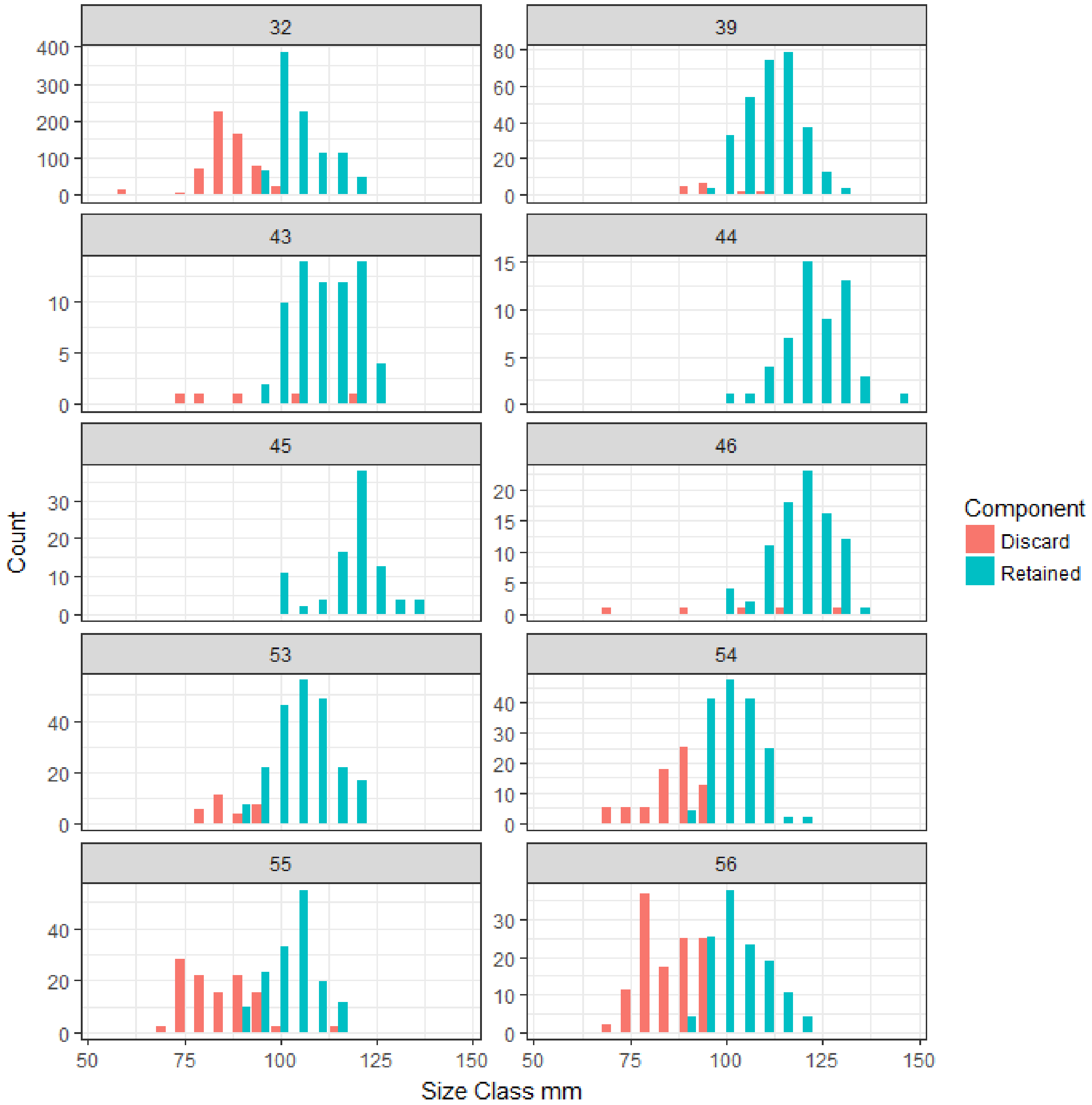



Figure 4.5.1 Example of scallop size distributions. N.B. The length distributions presented in the report are shell height.

Length samples of both commercial and undersized components of the catch are presented for eighty-nine tows (ten above and remainder appendix 4).

The minimum scallop height measured from the commercial gear was 57mm and the maximum was 145mm. The largest scallop measured from the discarded component was 131mm (rejected as damaged) and the smallest scallop measured from the retained component was 75mm. Mean scallop sizes were 89, 108 and 97mm for discarded, retained and combined catch respectively. The modal size class was typically but not restricted to between 100 and 110mm. In some areas, younger year classes were present in significant quantities and in tows from these areas modal size was typically around 90mm.

## Age sampling

Thirteen size stratified samples were collected during the survey and ages of scallops at size will be determined at the laboratory by experienced staff using traditional annual ring counting techniques. The relationship between age and size for this region can be presented as region specific age/length keys. Age determination is necessarily a labour-intensive process and results for this aspect will be reported later.

## Bluetooth® calipers

The Bluetooth® calipers used on this trip have been successfully deployed on a fishing vessel prior to this study. In addition, this equipment was tested in the office prior to commencement of this survey. During this survey, we found the signal between caliper and receiving tablet was unreliable requiring numerous button presses before successful transmission. These problems necessitated us reverting to older technology and subsequent length measurements were recorded using paper and pencil.

## Experimental gear for pre-recruit scallops

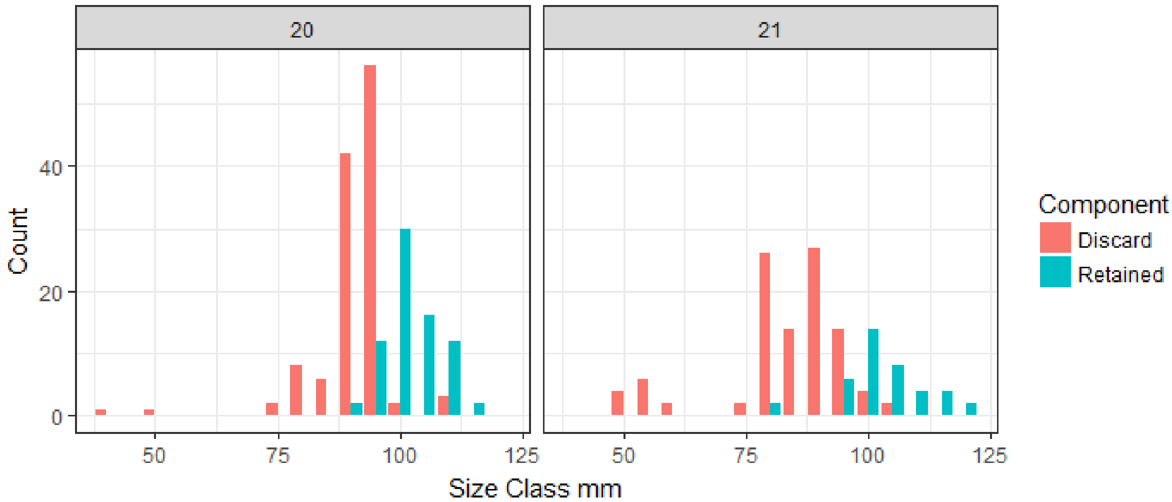



Figure 4.8.1 Size distribution of scallops from the experimental gear for tows 20 and 21.

The size distribution of the scallops taken in the experimental gear were similar to those taken in the commercial gear but there were a few smaller scallops representing a younger year class around 50mm shell height. These scallops were present but very rare in the commercial gear. The smallest scallop of 44 mm shell height was taken in the experimental gear.

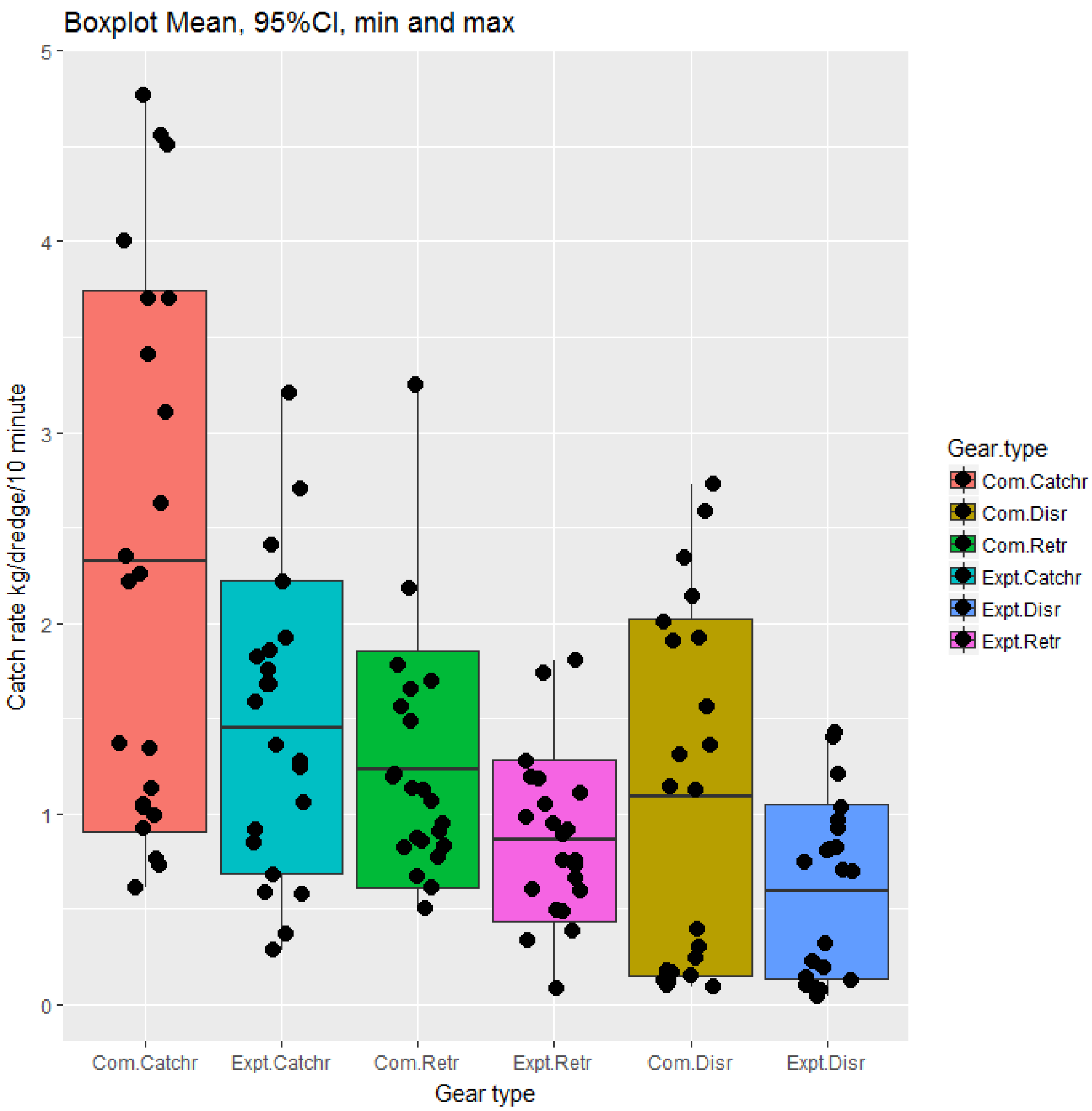



Figure 4.8.2 Total catch and discarded and retained components standardised to dredge number and ten-minute tow for commercial and experimental gear.

Catches for the experimental gear were generally lower than those from the commercial gear. Mean standardised catch in the commercial gear was 2.32kg compared to 1.46kg in the experimental gear. The mean catch of the discarded component were also higher in the commercial gear (1.09kg c.f. 0.59kg) and for the retained component (1.23kg c.f. 0.86kg).

Table x.

| Gear.type | min | max | mean |
|---|---|---|---|
| Com.Catchr | 0.611905 | 4.764286 | 2.324857 |
| Com.Disr | 0.091786 | 2.72625 | 1.091034 |
| Com.Retr | 0.507381 | 3.250714 | 1.233823 |
| Expt.Catchr | 0.283333 | 3.203333 | 1.456117 |
| Expt.Disr | 0.04 | 1.424167 | 0.593542 |
| Expt.Retr | 0.088333 | 1.801667 | 0.862576 |

A qualitative assessment of the fullness of each dredge suggested that for tows where the experimental gear was fitted with thirteen-teeth tooth bars the dredges were always full, usually with queenie shells (*Aequipecten opercularis*). On the same stations the commercial gear were typically only ¼ to ½ full. When the swords were substituted for eight-teeth tooth bars the experimental gear was typically only 2/3 to ¾ full.

# 4. Discussion

## Determination of optimum tow duration

Tow duration is an important aspect for any survey design to consider. Clearly the gear needs to be deployed on the seabed long enough to provide a representative sample that integrates over small scale variability and provides a robust estimate of density at a local scale. Like most animals, scallops are thought to be aggregated on the sea bed in areas that exhibit the right combination of physical and biological characteristics. Aggregated distributions require that the gear needs to be fishing long enough to give a significant probability that any high and low density patches of scallops are encountered by the gear and so that the average catch is representative of the area or stratum being sampled.

Surveys are usually limited by financial and logistic restraints and spending unnecessary time at each site will reduce the possibility of carrying out additional tows at sites elsewhere. Furthermore, long tow durations could lead to the dredges filling with either scallop, stones or by catch, creating a problem where the efficiency of the gear is subsequently reduced. Theory suggests that as the dredge fills a “bow wave” is created in its path and some scallop are swept to the side or over the top of the dredge. At some point, probably before the dredge is completely full, the dredge will stop fishing.

The optimum tow duration is a compromise and will be dependent on gear efficiency and scallop density at each site as well as the nature of the substrate and abundance of by catch species.

The tow duration study at the start of the scoping work was carried out in a part of the scallop fishery which may be considered typical in terms of scallop density and substrate type.

Results show that standardised catch rates at the “low-density” site did not show evidence of dredges filling up and catch rates reducing for all tow durations. However, in the “high-density” site there was obvious indication that the catch rate had declined during the 30-minute tow and during one of the tows during the 20-minute tows. This latter situation must be avoided to prevent underestimation of scallop density during subsequent surveys. These results do not give a definitive answer to the optimum tow duration but provide a useful indication of appropriate tow time. We propose further investigations and refinement as part of the longer-term program but suggest 15 minutes appears to be a good compromise based on these results.

## Spatial distributions

Before undertaking a fishing survey, it is desirable to understand the distribution of catches and their variability. Indeed, survey design could theoretically evolve in response to previous survey results to optimise the accuracy or certainty of the assessment. The French annual survey in the Baie de Seine follows this approach where sampling intensity in each stratum is related to variance in the catches in the previous year's results.

Analysis of the distribution of scallop in this survey area was therefore one of the priorities for this scoping work. It compliments work carried out previously by Cefas in the Western English Channel.

A geostatistical technique called kriging was used to predict or interpolate values between those points sampled. As well as providing a visual representation of these predictions, a semivariogram was produced to provide useful information on the continuity of data over distance. In geostatistical terms the distance on the horizontal axis of the semivariogram is called the range whilst the equivalent point on the vertical axis defines the sill. Within the range the data are said to exhibit some degree of autocorrelation which is a phenomenon where tows are close enough together that the value from one is related to the other. Sampling at a mean tow separation significantly below the plateau on the semivariogram plot provides diminishing returns in terms of increased robustness of the survey. Sampling at mean tow separations beyond the plateau on the plot will reduce the robustness of the survey.

Kriging can be used to estimate the total biomass of scallop within the sampling area and this method may well be used to determine scallop biomass from the forthcoming pilot dredge survey and subsequent surveys.

## Repeatability of catches

Paired tows were carried out to give an indication of the repeatability of the results. In other words, to indicate how representative the catch from one tow is for that immediate vicinity. Excessively variable catches from paired stations would indicate that the gear is not sampling consistently or there is considerable variability in the abundance on a fine spatial scale. The former would invalidate the results from any subsequent survey and the latter may necessitate such intensive sampling that such a survey would be financially unviable.

The results from the catch repeatability study show most tows had a high degree of comparability between the paired tows. This agrees with the geostatistcs which indicates that intermediate scale variability is higher than local scale variability and that stratifying surveys such that high density or high variability areas received higher station densities would seem appropriate.

The depletion studies also provided another indication of repeatability. Catch rates for the seven replicate tows for each study site were generally consistent (fig. 4.4.1). At the first site the catch rates ranged between 205 and 296 with a mean of 258kg/tow but the fitted line was flat suggesting a level of consistency from the start to end of the study. At the second site catch rates ranged from 81 to 115 with a mean of 93kg/tow.

## Gear efficiency

Understanding the relationship between survey catches and population abundance or biomass is a prerequisite for our stock assessment. Without this link our survey catches would only provide an index of abundance rather than the absolute abundance.

The results from the two depletion exercises failed to demonstrate a significant decline in catch rates and therefore makes this approach unsuitable for the determination of gear efficiency. We estimated that 34 dredges would provide sufficient fishing power to deplete the population of scallops in the path of the gear if towed over the same track repeatedly, and that after a few tows the catch rates would reduce. Plots of catch rate against cumulative catch should, in theory, provide a fitted line with a negative slope and per the Leslie model the slope would be equal to the catchability. The intercept on the horizontal axis should equal the initial biomass (as we were using units of weight rather than numbers).

A slightly different depletion design was used in a Cefas study in the Western English Channel in 2002. Here a vessel with fewer dredges was used and the vessel carried out several passes in a spatially defined box (1854x100m). Results indicated that catchability and efficiency was low and dependant on substrate type. Values of catchability (q) ranged from as low as 0.07 to 0.36 and were higher on clean ground and lower on ground with significant numbers of stones or rocks (equivalent to 11 and 58% efficiency).

It was thought that given the increased fishing power of the vessel used for this trial over that used for the earlier trial that a repeated track method would provide noticeable depletion. We suggest 4 hypotheses that could account for the lack of observed depletion:

1) Tracks were not covering the same ground
2) Changes to the benthos with successive tows increased the catchability of the scallops which compensated for the decline in abundance
3) Scallops were actively redistributing on the ground to fill the space left by the removals, or were attracted to the disturbed ground, although there is no known mechanism for this.
4) The efficiency of the gear was improving over the course of the trial

This study did show that determining catchability using depletion methods is not straightforward and we need to pursue an improved methodology or alternative technique to determine this critical parameter. This will be done later and could potentially be done retrospective of the first survey.

## Length sampling

The size structure of the catch is a function of gear selectivity and the size distribution of scallop on the ground. Gear selectivity is dependent on many factors which will include, perhaps in order of importance, belly ring internal diameter (ID), number of teeth on the tooth bar, mesh or ring size in the back of the dredge and other, less obvious gear characteristics. The Minimum Landings Size in the Eastern English Channel (Area VIId) is 110mm shell width and the internal ring diameter on the belly of the commercial gear was 85mm.

Measurements of either shell size metric (height and length) can be easily converted to the other using the relationship between shell height and length, but to ensure current and regionally relevant parameters are used for conversion the relationship between shell metrics will be examined during the dredge surveys.

The size structure of the scallops acquired from this study and their spatial distribution are informative, but they will achieve their full potential once converted to age using the relationship between size and age. Although the relationship between the two scallop size metrics shell height and length is available from earlier studies, it is known to vary regionally and it is proposed that size stratified samples of scallops will be measured for both metrics on subsequent surveys to ensure a precise conversion for all areas.

## Age sampling

Age samples taken from this survey are stored at the Cefas Lowestoft Laboratory awaiting age determination and to construct age/length keys. These will be applied to the length samples already acquired to provide an estimate of the age structure of the catch. To be reported elsewhere.

## Blue tooth callipers

The data transmission problems encountered with our radio transmitting digital Vernier calipers forced us to use a less efficient method of capturing the data (pencil and paper). This can also lead to transcription errors and attempts will be made to find a solution for future trips. A hard-wired system may be the answer for this application but other radio transmitting options could be tried.

## Experimental gear for per-recruit scallops

The aim of using the experimental gear is to facilitate sampling of pre-recruit scallops otherwise not retained by standard commercial gear. This could provide an indication of future recruitment to the fishery.

The size distributions from the few samples taken from the experimental gear show that a few individuals of a younger year class were present. Catch rates from the experimental gear were however consistently lower than those from the commercial gear (for all components of the catch, retained and discarded) and this is likely due to the gear not fishing well. With the thirteen-teeth tooth bars the bag of the dredge was always full of shell (mainly queenie) even in the ten and fifteen minute tows. After fitting the eight-teeth tooth bar the bags were not completely full but consistently contained more bulk than the commercial gear which fished much cleaner as was expected.

The difficulty is to use a design which fishes synchronously with the commercial gear without filling completely as this gear is designed not to fish cleanly. It is assumed that the experimental gear filled early in the tows, and stopped fishing effectively. The skipper suggested that the experimental gear was digging in too deep because of the length of the frames compared to the commercial gear being fished on the same beam.

The performance of the experimental gear was discussed at length with the skipper who made the following suggestions for future surveys: The backs should be made from larger meshes, tooth bars should have less than thirteen teeth but more than the eight of the commercial gear (nine was suggested), the frames should be the same length as those of the commercial gear.

## 5. Conclusions

1. A fifteen-minute tow should provide adequate coverage of the seabed and allow the gear to fish consistently during the tow in most situations.

2. A semivariogram produced by the geostatistical technique (kriging) suggests that the mean density of sampling in this area should be consistent with tows approximately 15-20km apart.

3. Catches from paired tows suggest that results are generally consistent and replicate tows are not required (diminishing returns).

4. Two depletion studies where the same tracks were towed repeatable did not show an obvious reduction in catch rates at each site, highlighting the need for a modified or alternative methodology to determine gear efficiency.

5. Length sampling facilitated construction of size distributions of the catch throughout the survey area.

6. The Bluetooth® calipers tested were found to be unreliable for measuring and capturing scallop size data and alternative technology will need to be considered for subsequent surveys.

7. The experimental gear retained a younger year class of scallops than the commercial gear but did not fish well alongside the commercial gear and further modifications as recommended by the skipper are planned for subsequent surveys.

## 6. References

R Core Team, 2006. A Language and Environment for Statistical Computing. R Core Team. Vienna, Austria, 2016

# 7. Acknowledgements

This project was carried out collaboratively between Cefas and MacDuff Shellfish Ltd. Funding was provided by Defra. We would like to take this opportunity to thank those who contributed to the success of the project, in particular the skipper and crew of the fishing vessel Sylvia Bowers and my colleagues at Cefas.

## Appendix 1. Request for Quotation (Invitation to tender)

**Request for Quotation**

**To:** Whom it may concern

**From: Andy Lawler**

**Tel: 01502 524219**

**Date of Issue: 5th September 2016**

**Response Deadline:** 17:00 on 17/09/2016

*Late submissions will not be accepted*

**Responses to be sent to:** andy.lawler@cefas.co.uk

**Title:** Request for Quotation for **Commercial scallop fishing vessel hire to assist us with our research surveys designed to determine the status of scallop stocks in the English Channel and Celtic Sea.**

**Technical Specification (Schedule 1)**

Background to Requirement:

Cefas in collaboration with industry will be carrying out a research project in the scallop fisheries and adjacent areas located in the English Channel and Celtic Sea with the aim of determining stock status. This will involve determining the distribution and abundance of the whole stock and will require sampling within currently fished grounds and areas outside.

These studies require one or two fishing industry collaborators with an interest in the sustainability of the stocks, local knowledge and experience of this fishery. The project is funded partially by Defra (Department for the Environment, Fisheries and Aquaculture Science). Defra and Cefas are committed to promoting the long-term future of the UK fishing industry and achieving Good Environmental Status under the Marine Strategy Framework Directive.

This project will set the foundations for long term monitoring and assessment of scallop stocks in English Waters. In the immediate term, some scoping will be carried out this year (2016) and we are planning to carry out the first full dredge survey next year (2017/18).

These aims will require taking up to two scientists to sea to determine the catches in standard and modified scallop dredges, **and you are invited to tender for the work to be undertaken this year (before 30th November). Although a separate request for quotations will be issued for subsequent years we would like vessel owners to also provide separate quotes for the first full survey due to start in 2017 and to assist us with our funding application.** Further details are given below.

The primary aims which require industry cooperation are:

**Investigate factors thought to influence scallop catchability**

Scoping this year will require the use of commercial fishing boats to fish for scallop using standard and modified dredges and in a manner to enable comparison of catches under different fishing conditions.

**Determination of the distribution and abundance of scallops**

This objective requires the use of commercial fishing boats to fish for scallop using standard and modified dredges to determine the distribution and abundance of scallop. To ensure the whole stock is monitored tows will be carried out on both existing fishing grounds but also in areas where scallop occur but are not currently fished. Modified dredges designed to catch smaller scallop below Minimum Landing Size (MLS) will be deployed at the same time as standard commercial gear to provide density estimates for pre recruit scallop. The fishing positions will be decided in consultation with the successful tenderer/s but will need to be representative of the whole scallop population, not just the areas that are commercially fished.

**Requirement:**

a) One or two experienced local skipper/s are required to assist scientists in creating a survey specification within the local scallop fishing grounds.

b) The vessel/s and skipper/s will be required for a minimum of 5 days and a maximum of 10 days. (The number of days required will be determined at tender evaluation stage dependent on location coverage provided in the tender submissions.)

c) The vessel/s and skipper/s will be required to deploy and service their own commercial gear and up to eight modified dredges provided. Tow positions will be confirmed after consultation with skippers, but flexibility is required as scientists will want to determine scallop density for the whole stock and fish areas which are representative of each area.

d) The skipper is required to provide their own commercial gear, and this is to be standardised throughout the survey as much as possible and kept in good condition for the duration of the survey.

e) Crew members would be expected to assist scientists with preparing the catch for sampling and recording results.

**TECHNICAL REQUIREMENTS-**

Cefas is seeking to commission a named and registered fishing vessel, including all management, crew, fuel, and other services necessary to fish in the manner defined below.

The vessel must be as specified in Appendix A.1.

Fishing gear and its operation must be as specified in Appendix A.2.

Fishing operations will be in the area specified in Appendix A.3.

Fishing operations must take place in accordance with the specification in Appendix A.4.

The Skipper must be named, must have experience of working the defined fishing gear in the defined area and must demonstrate that they have a track record of fishing for scallop in this particular fishery (with the defined fishing gear, in the defined area) as specified in Appendix A.5.

The vessel must satisfy accommodation and safety standards given in Appendix A.6

The Skipper is required to discuss with scientists and agree a Detailed Operational Plan as given in Appendix A.7 before work starts. This may be fulfilled by telephone conversation but may require attendance at a planning meeting with scientists. The tender price should include the cost of attending any meetings or telephone discussions.

**PRICE**

In the tender please provide three quotations as follows:

For **this year's scoping study** - An all-inclusive fixed price for the provision of all the services above, including attendance at meetings, the supply and repair of gear, crew, fuel and any additional insurance and accommodation for **5 days fishing. The price must include a breakdown of VAT.**

**1)** For **this year's scoping study** - An all-inclusive fixed price for the provision of all the services above, including attendance at meetings, the supply and repair of gear, crew, fuel and any additional insurance and accommodation for **10 days fishing. The price must include a breakdown of VAT.**

**2)** For **next year's dredge survey** - An all-inclusive fixed price for the provision of all the services above, the supply and repair of gear, crew, fuel and any additional insurance and accommodation for each fishing day during the first of the annual surveys to be carried out in 2017. This is a **daily hire rate** to assist with our funding application for next year. **The price must include a breakdown of VAT.**

**SPECIAL PROVISIONS RELATING TO RETENTION OF UNDERSIZED SCALLOPS IN CONTRAVENTION OF EC REGULATION 850/98**

**A dispensation will be provided to allow retention on board or landing of undersized scallop to facilitate this work. Local authorities will be kept informed as to the project requirements and any additional dispensations or permissions required to achieve the scientific objectives will be provided as required.**

**Quantity: 5 or 10 days**

**Delivery Date / Contract start date: Scoping work 30th September 2016**

**Contract Duration: 5 or 10 days to be decided at tender evaluation**

**EVALUATION OF THE TENDER**

All criteria of "What is Required" and Appendix A must be satisfied. The tender seeks to ensure delivery of the agreed science at an affordable price, so providing good value for money. All tenders will be evaluated and scored, and the highest scoring tenders, meeting all the criteria and offering best value for money, taking into account delivery and affordability will be selected, as funds allow.

Vessels will be subject to inspection prior to award of a contract.

**A.1 VESSEL SPECIFICATION & ACCESS**

The vessel must be a practicing commercial fishing vessel capable of deploying scallop dredges of similar specification to those typically used in this area.

The vessel must be capable of remaining at sea for a period of five days.

The vessel must have a safe working deck area, well lit, with sufficient clear deck area to accommodate up to two scientists and their equipment.

The vessel will have sufficient deck space to facilitate scientific sampling of the catch.

Embarkation and disembarkation should be at a port giving appropriate access to the fishing grounds.

<u>The tender must</u> state the name, type and size of the vessel.

<u>The tender must</u> state the port, or ports, they would suggest for embarkation and disembarkation.

<u>The tender</u> must confirm that the vessel is capable of remaining at sea for a five-day period.

<u>The tender</u> must confirm that the vessel and skipper will be available for a port visit by a Cefas scientist to assess the suitability of the vessel for the requirements of the survey.

**A.2 FISHING GEAR**

The fishing gear to be used will be:

- Modified and standard scallop dredges deployed mixed on each beam. Modified dredges with smaller ring size will be provided by Cefas. Repairs to be carried out by tenderer

<u>The tender must</u> confirm the vessel is suitably equipped to deploy and retrieve this gear.

**A.3 AREA OF OPERATION**

Fishing operations will be carried out in the English Channel and Celtic Seas which are located in ICES areas VIId, VIIe, VIIf, VIIg and VIIh.

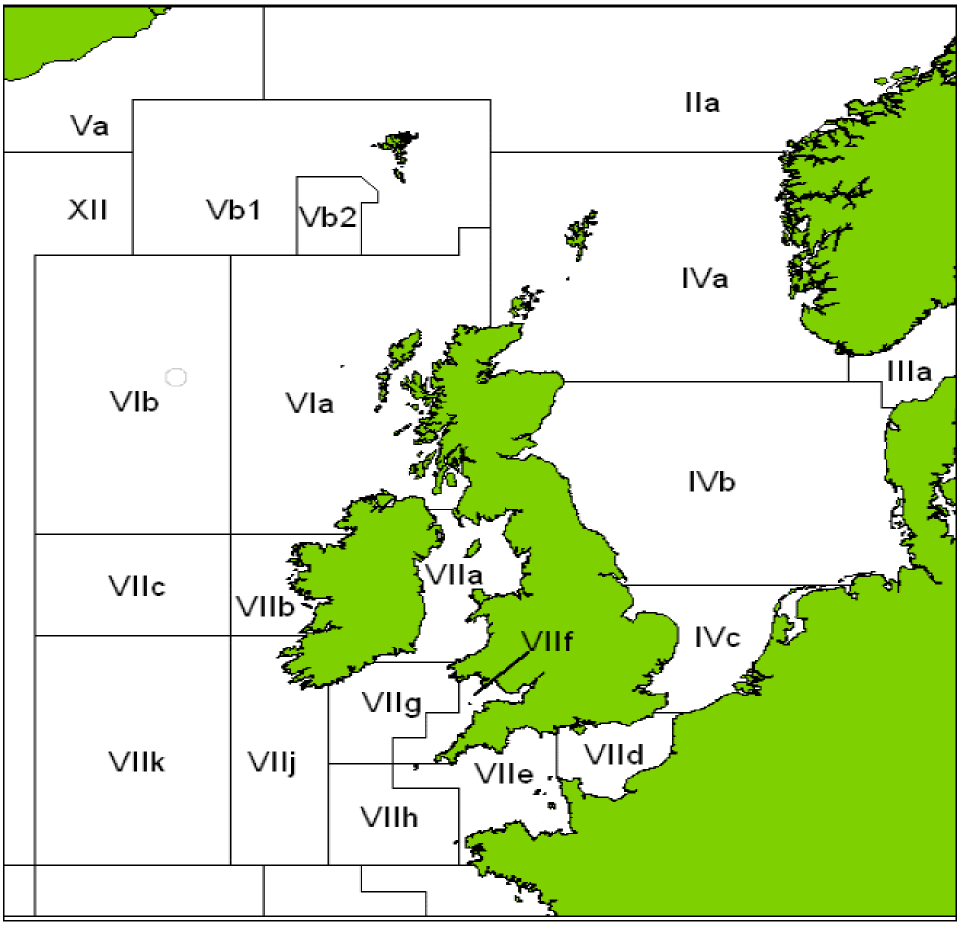



**Figure 1.** Location of operation within ICES subdivision VIId, VIIe, VIIf, VIIg and VIIh.

## A.4 FISHING OPERATIONS

Fishing operations must take place in accordance with the following:

**A 4.1 Period of project:** The dredge survey shall start as soon as possible after 30$^{th}$ September and be completed by the end of October 2016 (weather permitting). The exact timing and other details will be agreed in the Detailed Operations Plan of A.7.

**A 4.2 Duration of project:** The dredge survey requires between 5 and 10 days fishing to be spread throughout the sampling period.

Days at sea will be subject to weather conditions and vessel availability. In the event those days at sea are lost through adverse weather conditions or vessel availability, the lost day(s) must be re-scheduled for the earliest opportunity. Details will be agreed in the Detailed Operations Plan under A.7. The 5-10 days does not include an allowance for days lost to bad weather.

**A4.3 Fishing Activities:** Fishing activities will be required for approximately 5-10 days (depending on start date) with the specified gear deployed and fished as is typical for commercial practice. Note that scientists may require the gear servicing procedure to be slowed to enable enumeration of the catch and any necessary sampling procedures to be carried out (see A.4.4 below). Fishing practice may be altered during the survey period and will be agreed in the Detailed Operations Plan.

**A 4.4 Sorting the Catch and recording:** The crew will be required to assist in sorting and processing the catch and to assist in handling any scallop to facilitate biological sampling by the scientists where appropriate.

**A 4.5 Commercial Fishing: The scientific survey aims may be modified throughout the charter period and must be fulfilled. We advise that in formulating a quote the tenderer assumes there will be no commercial fishing.**

<u>The tender must</u> confirm the number of days the vessel, Skipper and crew will be available for.

<u>The tender must</u> confirm that the required fishing will be undertaken throughout the specified area.

<u>The tender must</u> confirm that the crew will be willing and available to sort and process the catch and record data.

<u>The tender must</u> confirm that the fishing activities agreed in the Detailed Operations Plan will be undertaken.

**A.5 EXPERIENCE**

The Skipper must be named and have a track record of fishing for scallop in 2015 and/or 2016, using standard scallop dredges from the survey area defined in A.3. The Skippers' experience is crucial to the success of the project, and tenderers are encouraged to describe fully that experience. This will be a significant part of the tender evaluation.

<u>The tender must</u> detail the experience of the Skipper as required above.

<u>The tender must</u> include supporting evidence of the type of gear used for catching scallops.

**A A.6 WORKING ENVIRONMENT AND SAFETY STANDARDS**

**A.6.1 Accommodation:** The vessel shall provide a covered area with sufficient space to accommodate up to two scientists and crew from adverse weather.

The vessel shall provide a safe working area, which will be well lit under all sea conditions, and large enough to accommodate the scientists and their equipment.

If the vessel is at sea overnight the vessel shall provide suitable sleeping accommodation for two scientists and the crew.

the vessel shall provide food for the scientists.

<u>**The tender must** describe how the accommodation standards above are met, and give details of the size and character of the scientist's working area.</u>

**A.6.2 Safety Standards:** (These are the normal standards required for fishing vessel operations)

The following is required for the vessel:

**a)** i) The vessel must have and supply a copy of a valid Marine & Coastguard Agency Fishing Vessel Decal certificate issued by an appointed MCA surveyor after inspection to ascertain the vessels general seaworthiness and compliance with The Small Fishing Vessels Code of Practice for Fishing Vessels under 15 metres LOA.

ii) If a mid-term inspection has been carried out by the MCA a copy of the report must be supplied.

iii) A copy of the declaration for annual self-certification under The Code of Safe Working Practice must be sent with the tender.

**b)** All vessels must have adequate marine insurance cover for the size of vessel and personnel on board.

The tender must supply a copy of the insurance cover for the vessel and personnel on board including scientific staff. (You may wish to detail your P&I and personnel insurance and financial limits on each)

c) All vessels must comply with the National levels of certification applicable to the area of operation and size of the vessel in respect of

Deck officers and engineers.

d) All vessels must comply with the applicable code on safety equipment such as: Liferafts. Lifejackets, Distress Rockets & flares, Radio Equipment and First Aid consumables.

The tender must confirm that the number of working liferafts are adequate to cover both the ship's personnel and Cefas personnel.

e) All crew on all vessels must have completed the Four x one day -

mandatory safety courses - Sea survival, First aid, Fire fighting & Safety awareness.

The tender must confirm that all crew will have these certificates and they will be produced at the first detailed meeting and prior to sailing.

f) All vessels must comply with the Marine & Coastguard Agency safe manning levels in accordance with size of vessel and area of operation.

g) The MCA advises that it is good practice for vessels to have a written risk assessment.

The tender must confirm whether they have a risk assessment and supply a copy of the risk assessment if they have one.

h) Prior to contract award an inspection of the vessels' lifesaving equipment will be carried out by a qualified surveyor.

The tender must confirm the vessel will be made available for an inspection on the vessel's lifesaving equipment.

In addition to the standards given above, Cefas also requires that:

i) The tender must confirm that there is a prohibition on the carriage of illegal drugs and alcohol.

Tendering vessels should ensure that they fully meet the requirements of the relevant code.

**A.7 DETAILED OPERATIONS PLAN MEETING**

The Skipper is required to be available for a meeting in early September 2016 for the development of a Detailed Operations Plan. This will involve scientists and the Skipper discussing the project objectives, and the joint development of details and structure of the Operations Plan. A further meeting may be needed to finalise a Detailed Operations Plan which will be required to be agreed no later than one week before the date of first sailing.

The tender must confirm the Skipper's availability for such meetings.

Cefas reserves the right not to fund any project or award any contract.

The tender will be evaluated as follows:

Quality 70%

Cost 30%

**Submitted Pricing (Schedule 2):**

| Good or Services Required | Qty | Unit of Measure | Cost | VAT | Delivery Date |
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| | | | £ | £ | |
| | | | £ | £ | |

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| | | | £ | £ | |
| | | Total Cost: | £ | £ | |

We understand and accept that **Cefas' Standard Terms and Conditions for Services** apply to this project and any subsequent work.

| | |
|---|---|
| Signed: | For:<br><br>(Company Name) |
| Name:<br><br>(Block Capitals) | Date: |
| Name of contact to call in the event of a query (if different from above): | Direct telephone number of contact: |

# Appendix 2. Detailed Operation Plan

## Scallop Stock Assessments in English Waters – Scoping Studies

Testing methodologies for scallop dredge surveys in the English Channel: November 2016

***c)*** *Detailed Operation Plan (as agreed 4th November 2016)*

### VESSEL

FV Sylvia Bowers (DS8)

Skipper: James Spencer

### SCIENTISTS

1. Andy Lawler (Cefas)
2. Chris Barrett (Cefas)

### OBJECTIVES

9. To determine the optimum tow duration for the dredges and the repeatability of catches.

10. To determine the fine scale spatial distribution of scallop in an area of the Eastern English Channel.

11. To determine the efficiency of the scallop dredges on different ground types in the Eastern English Channel.

### FISHING GEAR

The fishing gear will be Newhaven dredges provided by the vessel but Cefas will provide 4 dredges to provide catches of undersized scallops for objectives 1 and 2 (scientific gear). These 4 dredges will be similar in construction and weight to queenie dredges and fished alongside the standard gear (substitution of four commercial dredges). The gear will be deployed and recovered by the vessel crew. The crew will process the catch as requested by the scientists to facilitate quantification and sampling in line with the survey aims. The crew will service the commercial gear as necessary to provide consistent fishing efficiency.

## AREA OF OPERATION and FISHING POSITIONS

Fishing operations will be based from Shoreham and carried out on fishing grounds in the Eastern English Channel. Operations will be restricted to areas outside 6 nautical miles of the coast and outside of restricted areas such as Marine Protected Areas. A fishing area exhibiting grounds with contrasting scallop densities and substrate types should be chosen.

The skipper should provide full gear specifications for his own gear and, at the end of the survey, a copy of the station positions as well other details of each fishing operation (log sheets to be provided by Cefas).

## SURVEY PROCEDURE

Obj. 1 - Survey site locations which provide good scallop catches and a variety of ground types will be sort in consultation with the skipper. A site which fishes cleanly and sites which provide significant bycatch and debris (rocks or stones) will be chosen. At each of these sites three 10 minute tows and three 15 minute tows will be carried out, followed by three 20 minute tows and three 30 minute tows (12 tows at each site). The tows will be carried out near each other but avoiding towing over ground already covered by earlier tows.

Obj. 2 - Several additional sites will be chosen in agreement with the skipper and so that the centres of each site are 20km apart. The number of sites to be sampled will be determined by the time available.

At each site 5 tows will be conducted in a 5km radius. The duration of these tows will be determined by the findings from the first study. An additional 2 tows will be carried out at each site and parallel to two of the earlier tows so that the gear fishes close to but not over the same ground as that fished earlier.

Obj. 3 - At several sites which exhibit different ground types e.g. clean or rocky, the gear will be operated repeatedly to deplete the population of scallops in a plot 1860m x 100m.

## DURATION OF SURVEY

The survey work will be completed in 6 fishing days but if fishing operations are not carried out consecutively, the remaining duration of the survey will be carried out as soon as possible. If weather conditions are not suitable for representative fishing to occur operations will be postponed.

## DATA TO BE RECORDED BY SCIENTISTS

The scientists will produce a length distribution for the commercial gear and scientific gear at each site (obj. 1 and 2). The scientists must ensure that all length frequencies and raising factors are fully and correctly entered on the recording sheets and that all wheelhouse log sheets and any biological sampling sheets are collated at the end of each sampling day. A crew member may be required to assist the scientists with data recording for the duration of the survey.

The scientists must ensure that data is secure and that it is processed and analysed in a suitable manner on return to the laboratory.

## CRUISE REPORT

The scientists will maintain a diary of activities, including an electronic copy where possible, and a draft cruise report in standard Cefas format will be prepared by Cefas. The cruise narrative should be read and agreed by the skipper (report will bear the sentence “seen in draft by skipper”).

## COSTS

The cost will be those specified by the tender document, and in this case will amount to £4819 for each full day charter for the dredge scoping survey undertaken during October.

It is anticipated that payment will be made at the end of the charter period.

Signed:

………………………………….. (skipper)  ………………………….(date)

……………………………………(Cefas)  ………………………….(date)

# Appendix 3. Trip Report

## Scallop Stock Assessments in English Waters – Scoping Studies

Testing methodologies for scallop dredge surveys in the English Channel: November 2016

***d)*** *Trip report (as agreed 21st November 2016)*

### VESSEL

FV Sylvia Bowers (DS8)

Skipper: James Spencer

### SCIENTISTS

Andy Lawler (Cefas) and Chris Barrett (Cefas)

### OBJECTIVES

1. To determine the optimum tow duration for the dredges and the repeatability of catches.

2. To determine the fine scale spatial distribution of scallop in an area of the Eastern English Channel.

3. To determine the efficiency of the scallop dredges on different ground types in the Eastern English Channel.

### SUMMARY

Scientists joined the vessel at Shoreham-by-Sea on the 4th November to discuss the survey plan with the skipper and crew. The vessel sailed at 0000hrs on the 5th November and steamed to the first survey site in the Eastern Channel. Fishing stations were undertaken at two sites and the catch was quantified to determine appropriate tow duration for this vessel and gear configuration (obj. 1). Four experimental dredges fitted with 55mm belly rings (queenie specification) and thirteen tooth swords were trialled.

The vessel started a grid of stations at 0115hrs on 6th November to determine the fine scale distribution of scallops in the Eastern Channel (obj. 2). Seven tows were carried out within a 5km radius at each site and where the sites were initially 20km apart (approximately). Fishing within 12nm of the coast, aggregate dredging areas and over the French median line was avoided so that the survey grid was not symmetrical.

At 1630hrs 7th November (tow 67) mechanical issues necessitated quayside repairs and the vessel docked at Shoreham at 0400hrs 8th November. A poor weather forecast prevented sailing until 0600hrs on the 10th November. Fishing resumed on the survey grid at 1030hrs but was interrupted at 1705hrs to carry out a depletion experiment at a site shown to be stony. Seven tows over the same track were carried out to deplete the scallops and reduce the catch rates (obj. 3). The track was approximately 1500m long. This was abandoned as catch rates after seven tows were as high as that on the first tow and the vessel resumed the survey grid 0150hrs 11th November.

At 1410hrs a second depletion study was attempted on a single tow track in an area with clean ground but fishing on the survey grid resumed at 2235hrs.

There was enough time towards the end of the survey period to carry out tows at sites between the sites of the original grid.

The vessel docked at 0830hrs 13th November at Shoreham from where the scientists disembarked and returned to Lowestoft.

## RESULTS

Objective 1. Twenty-five tows were carried out at two sites to determine an appropriate tow duration for this vessel, gear configuration and fishing area. Twenty minutes appears to be a good compromise between providing an adequate sample and overfilling the dredges. More detailed analysis of the results to confirm this to follow.

Objective 2. Seven tows at fourteen sites (98 tows) were carried out to determine the fine scale distribution of scallops in this area. More detailed analysis will determine appropriate sampling density for subsequent surveys.

Objective 3. Seven tows over the same tow track at each of two sites failed to reduce catch rates indicating very low gear efficiency which could not be quantified during this survey. Modification of this methodology will be required if this is to be repeated on another occasion.

Sixteen samples were retained for future age determination and 120 scallop length distributions recorded.

In addition, experimental dredges designed to retain undersized scallops were tested. Modifications were tested and suggestions from the skipper for further design improvements noted.

## ACKNOWLEDGEMENTS

Thanks are due to the crew of the Sylvia Bowers whose dedication and expertise were an essential requirement for this survey.

Signed:

………………………………….. (skipper)          ………………………….(date)

……………………………………(Cefas)          ………………………….(date)

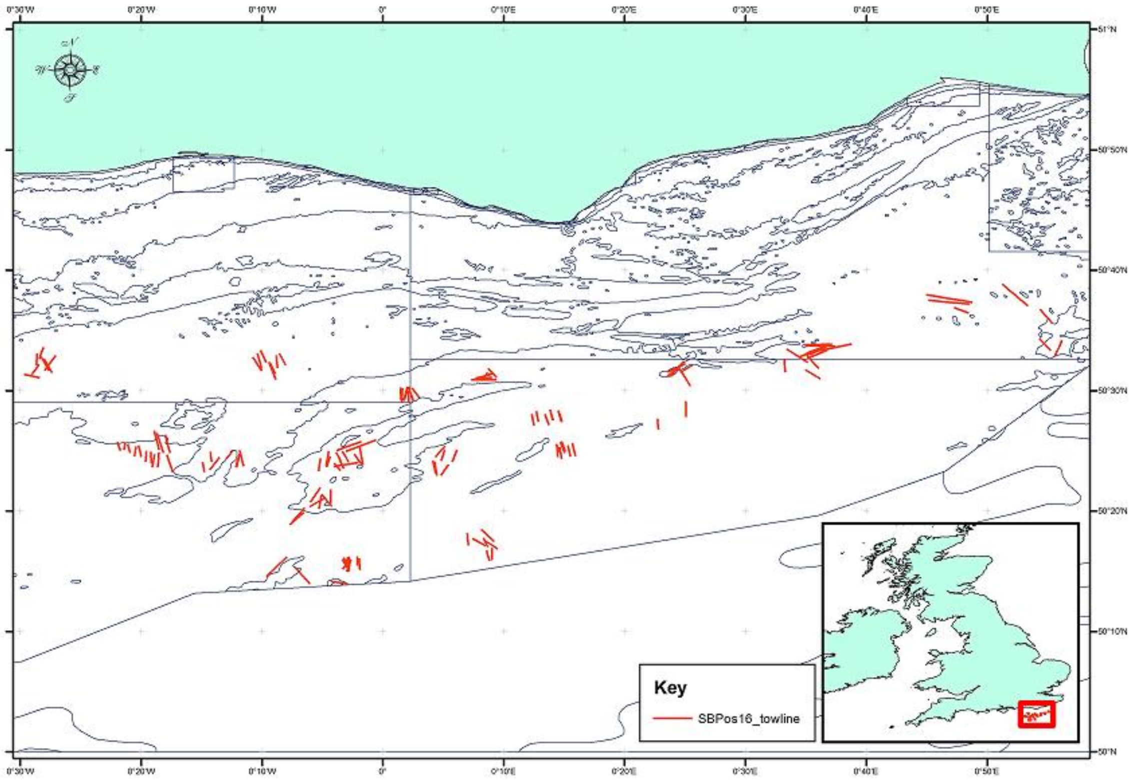



Figure 1. Tow start and end positions with assumed track

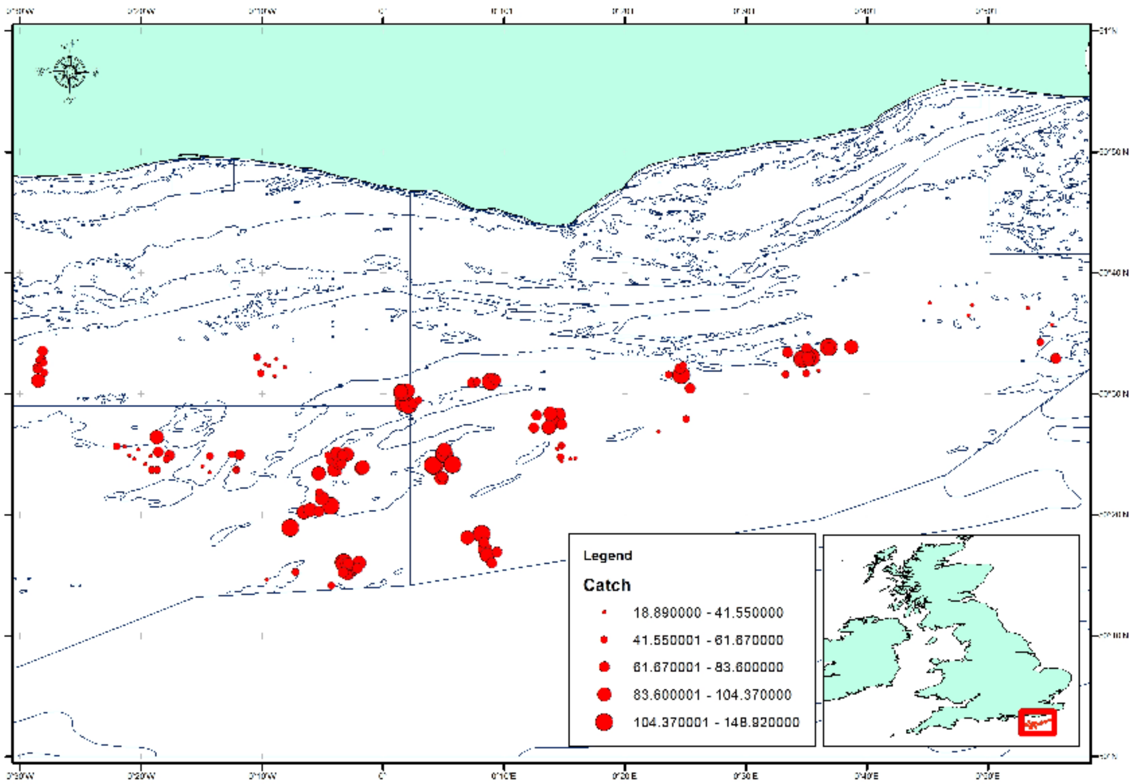
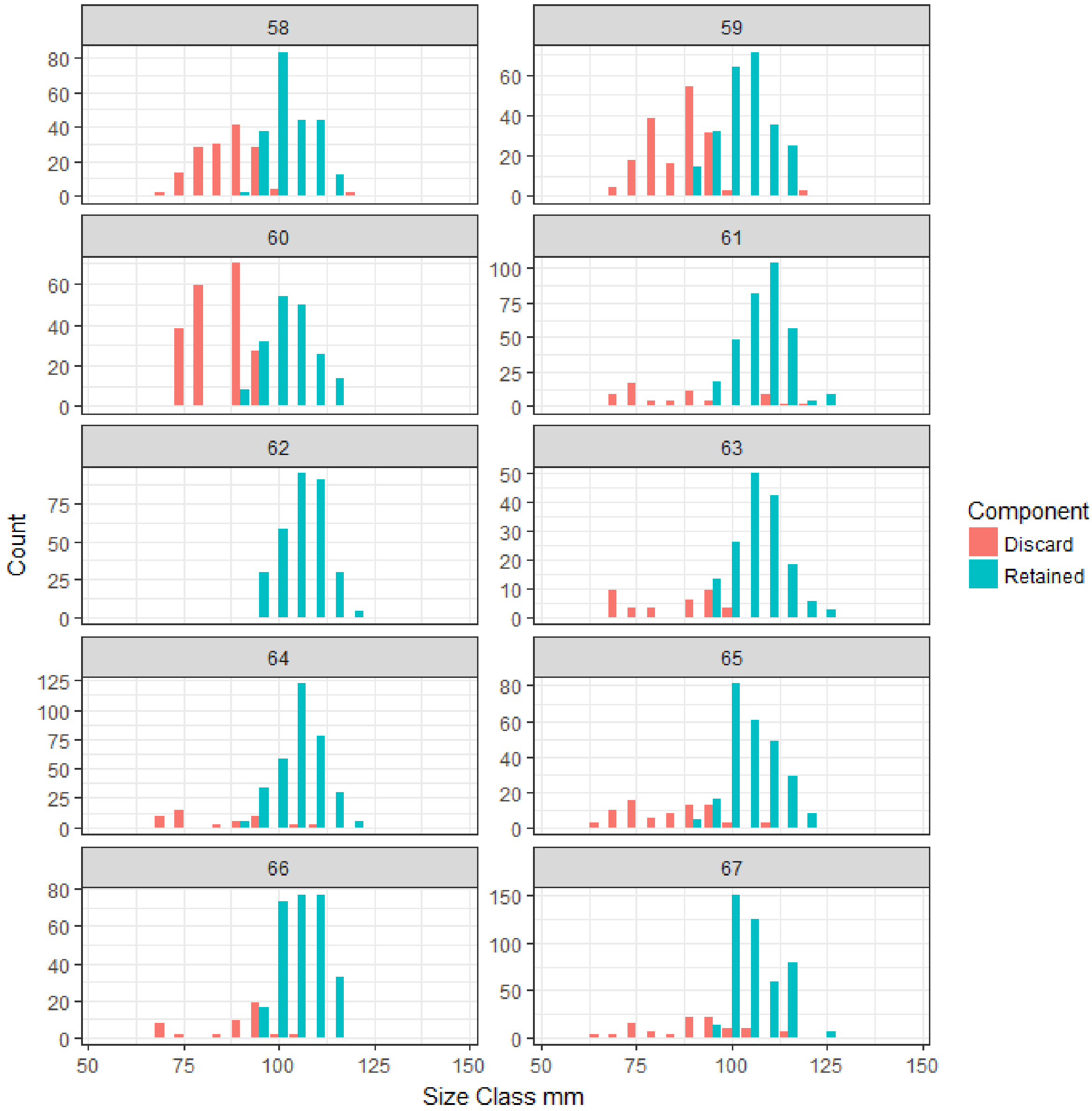
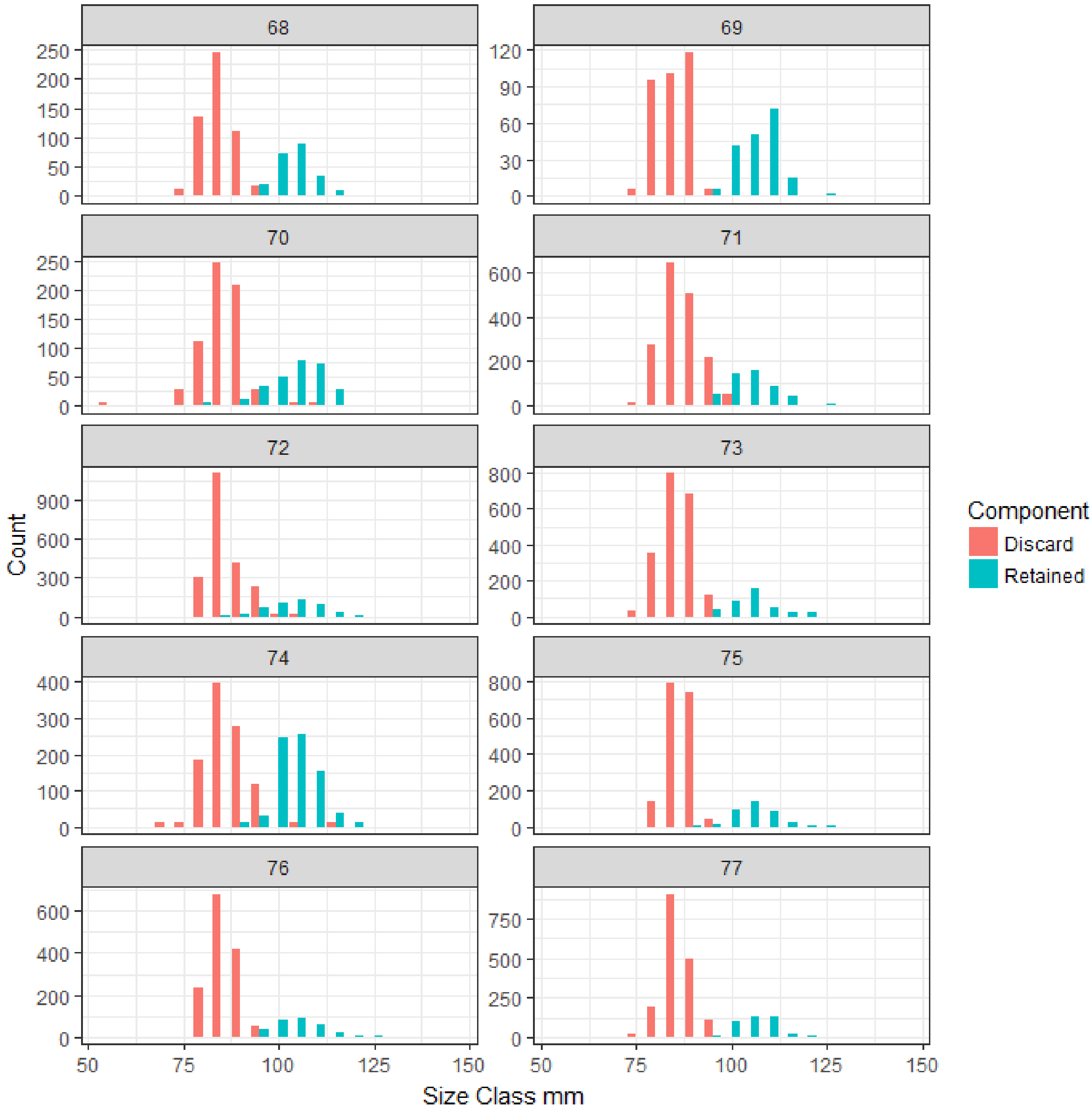


Figure 2. Provisional catches of commercial sized scallop by site. Bubble size proportional to catch.

## Appendix 4. Length Distributions

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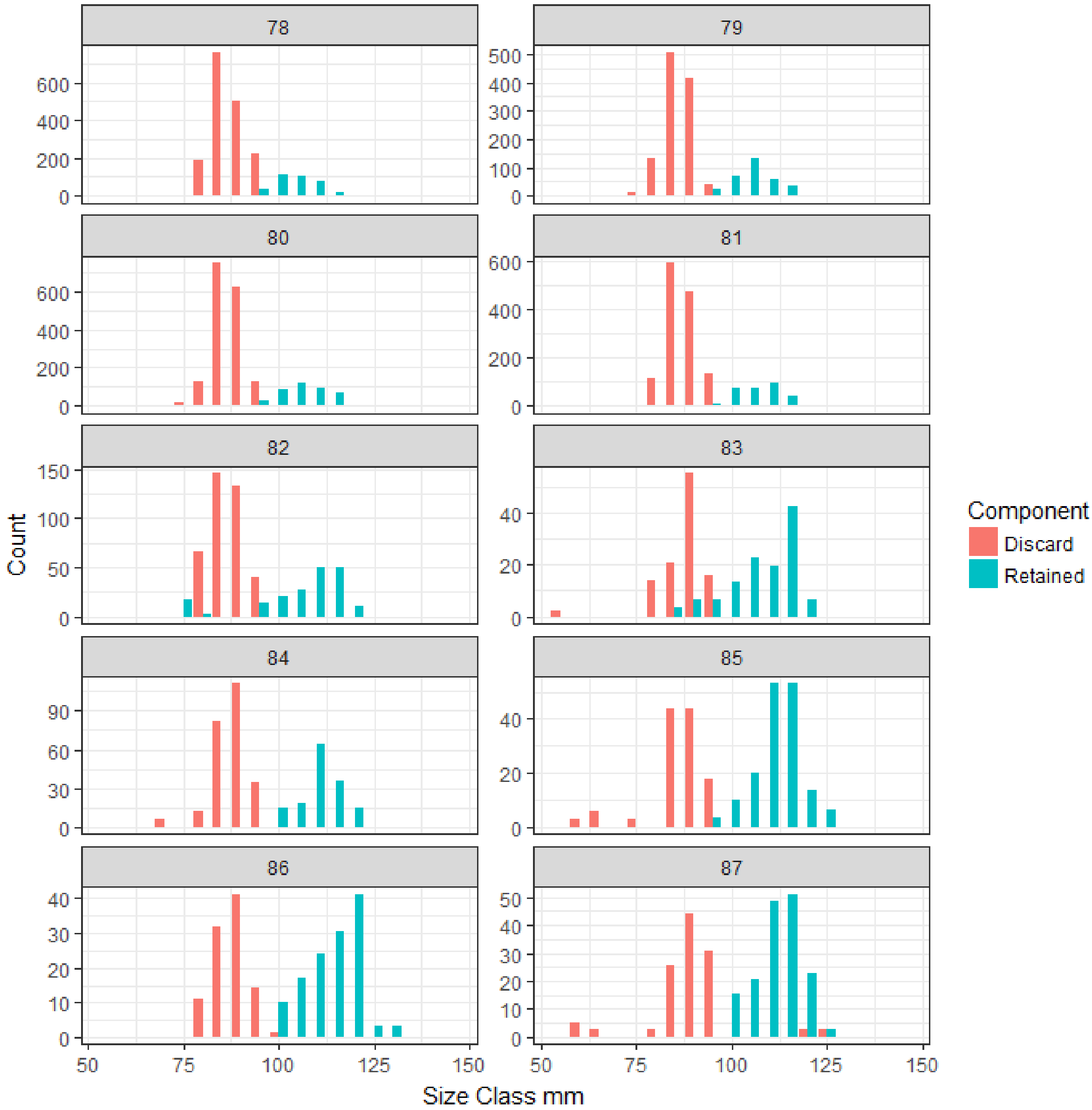
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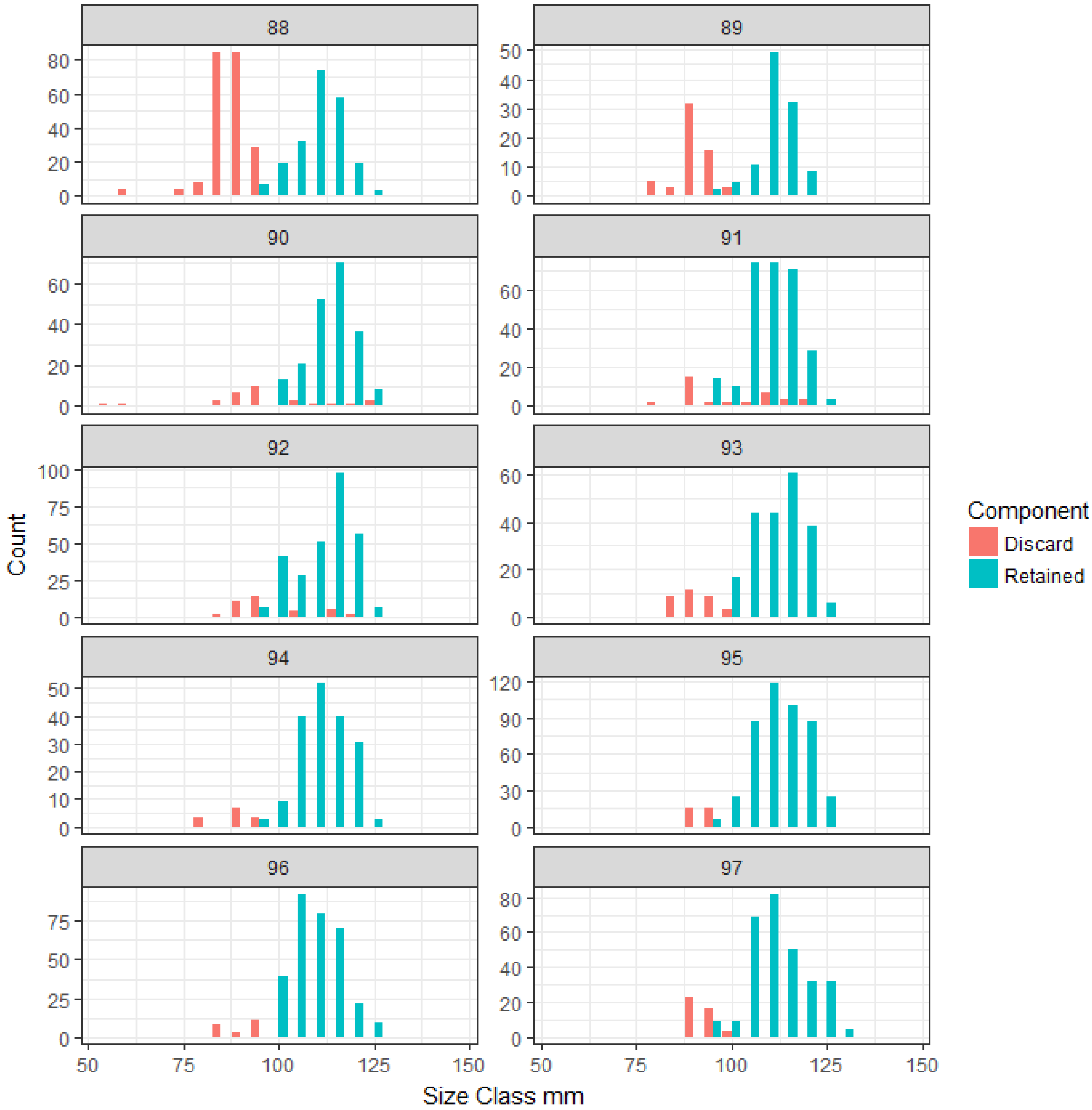

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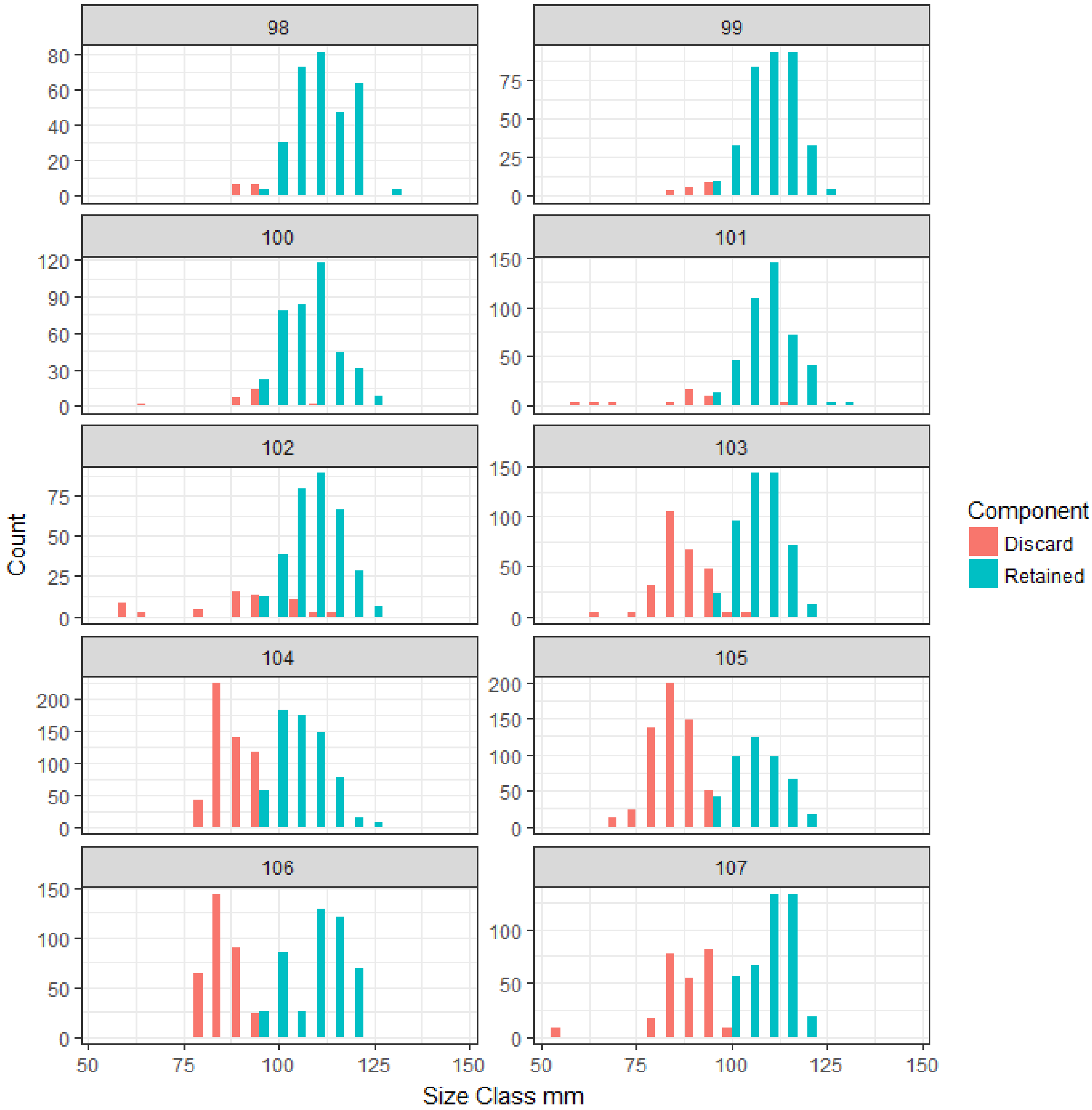
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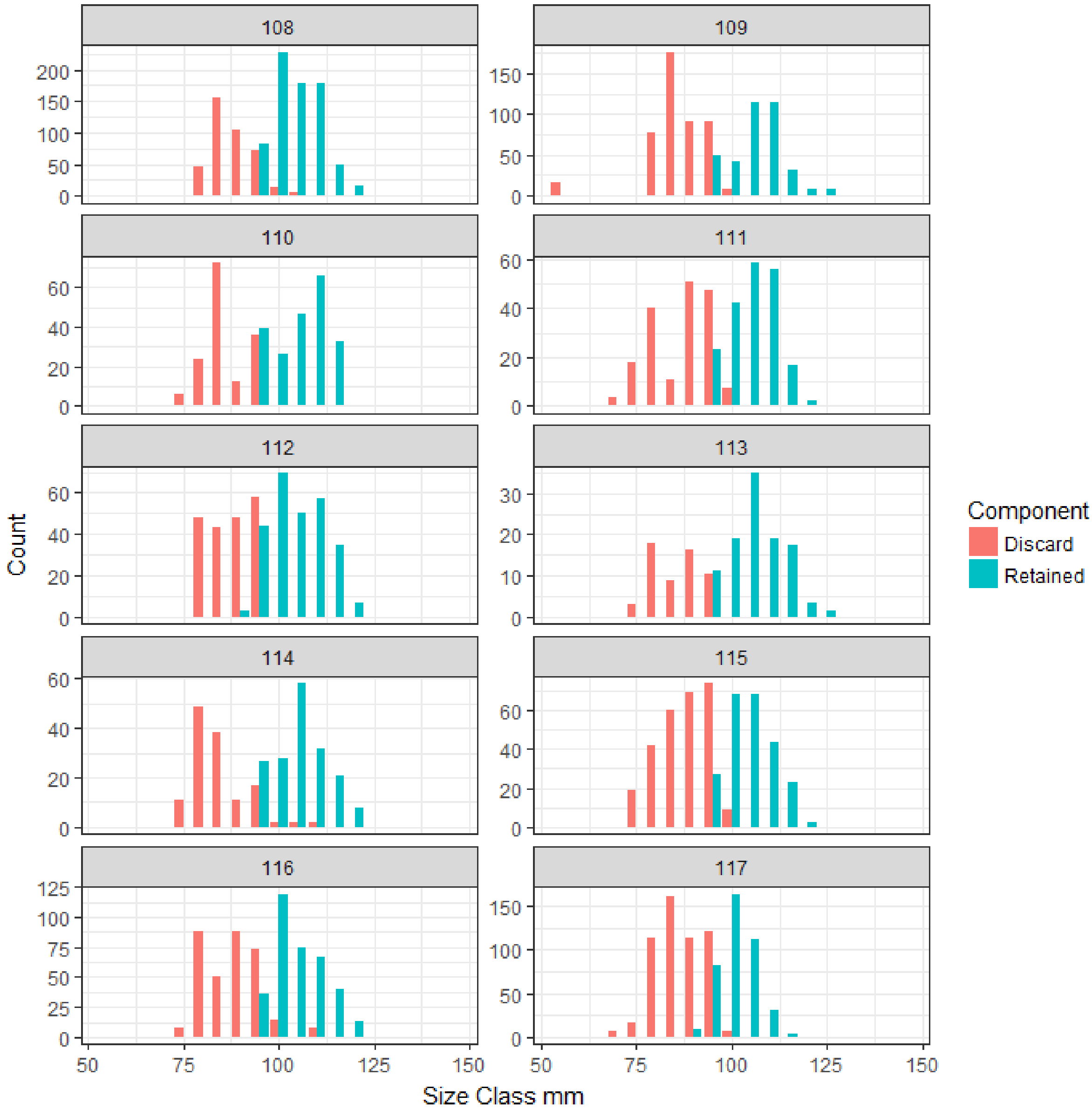
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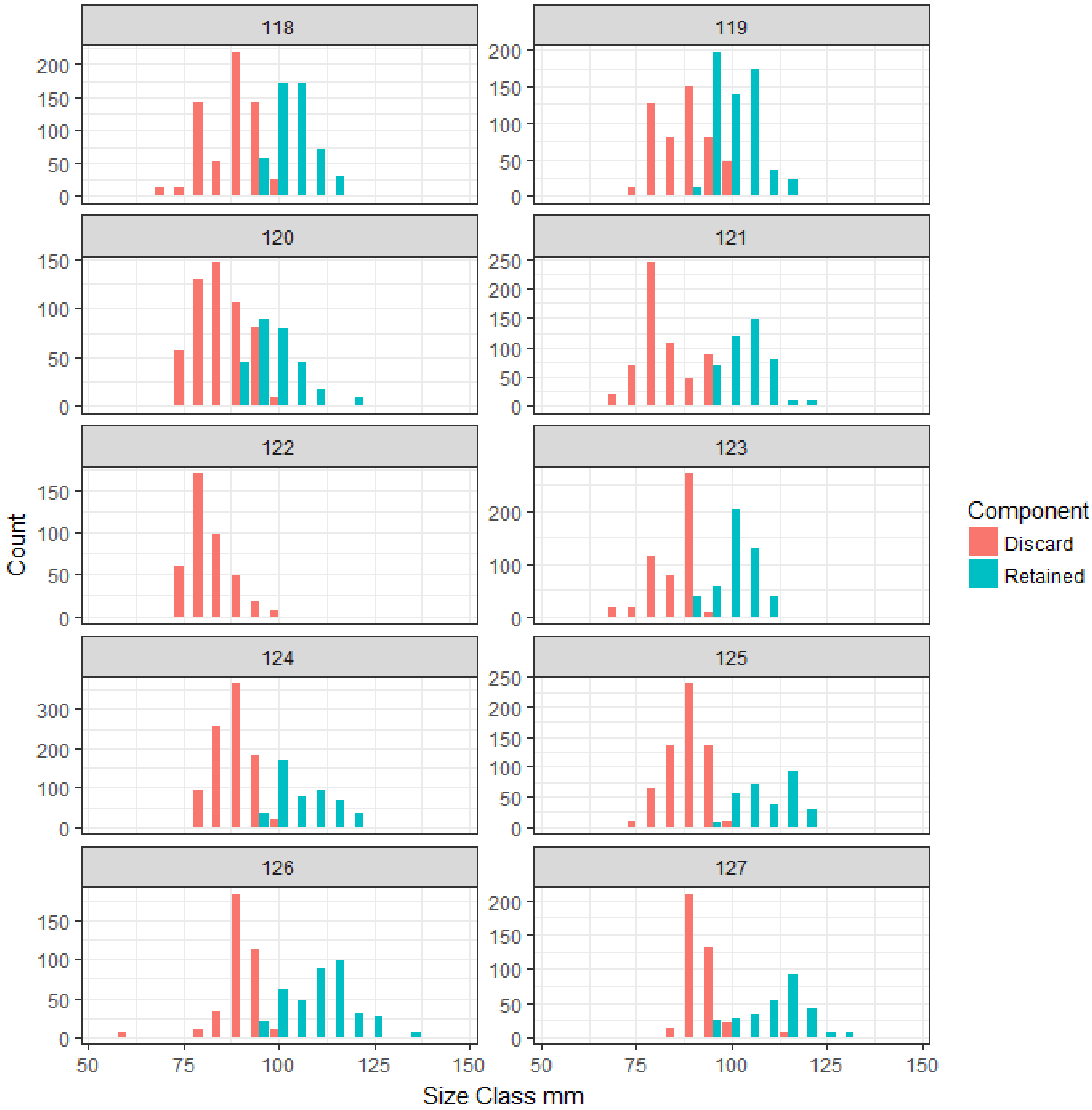
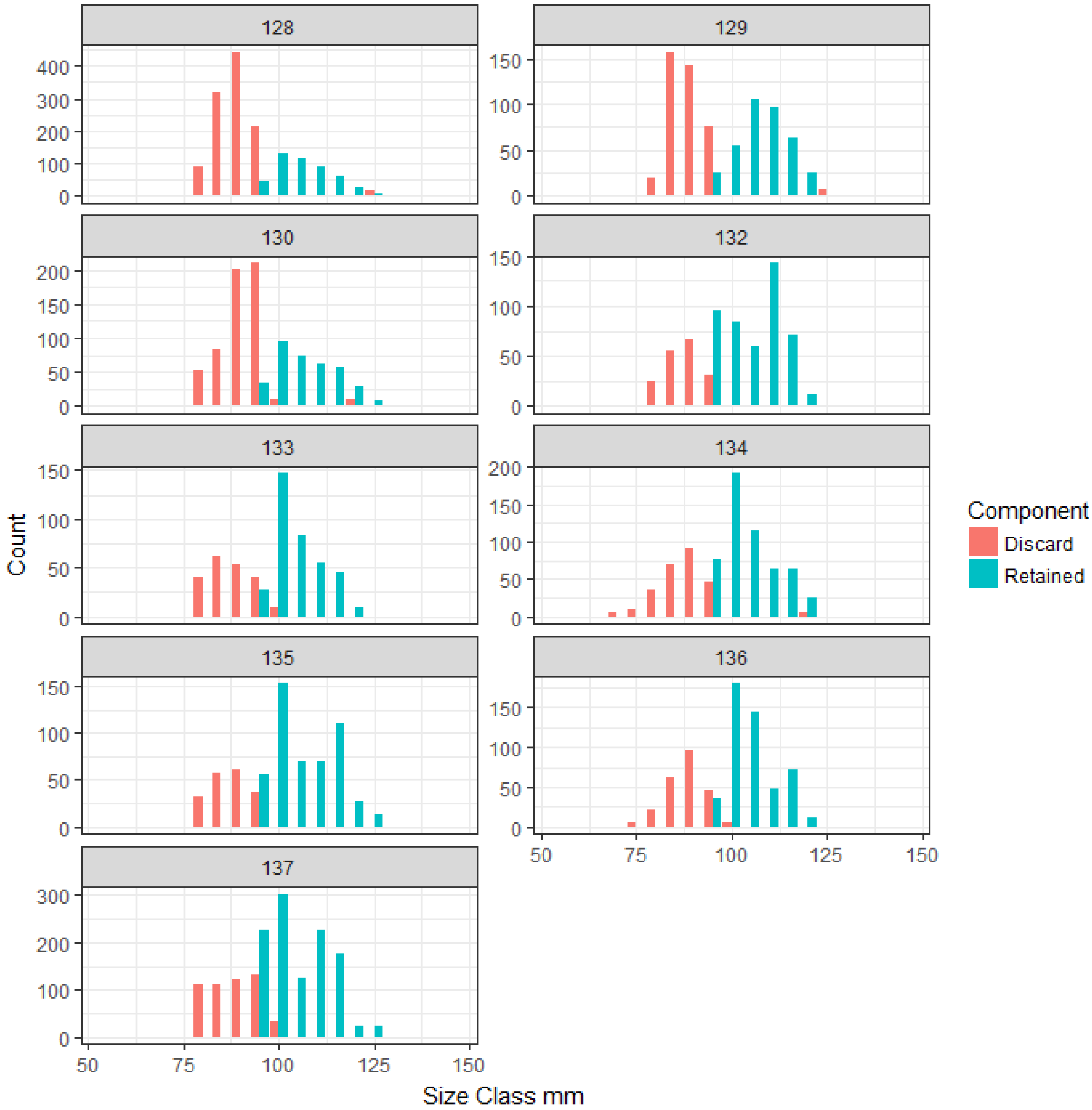


118
119
120
121
122
123
124
125
126
127
Count
Size Class mm
Component
Discard
Retained


128
129
130
132
133
134
135
136
137
Count
Size Class mm
Component
Discard
Retained

## Appendix 5. Summary details of tows and catches

TD-Tow Duration, SG-Spatial Grid, D-Depletion

| Site | Expt | Tow | Dur | Retained | Discard | Catch | Start.Lat | Start.Lon | End.Lat | End.Lon | Paired Tow | Dredge nos |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | TD | 1 | 10 | 51.93 | 5.6 | 57.53 | 50.428 | -0.366 | 50.418 | -0.363 | NP | 34 |
| 1 | TD | 2 | 10 | 24.57 | 4.93 | 29.50 | 50.415 | -0.349 | 50.425 | -0.352 | NP | 34 |
| 1 | TD | 3 | 10 | 25.85 | 2.91 | 28.76 | 50.427 | -0.356 | 50.419 | -0.357 | NP | 28 |
| 1 | TD | 4 | 15 | 41.83 | 7.13 | 48.96 | 50.410 | -0.343 | 50.422 | -0.341 | NP | 28 |
| 1 | TD | 5 | 15 | 39.07 | 8.4 | 47.47 | 50.423 | -0.337 | 50.410 | -0.334 | NP | 28 |
| 1 | TD | 6 | 15 | 21.84 | 5.56 | 27.40 | 50.403 | -0.327 | 50.415 | -0.327 | NP | 28 |
| 1 | TD | 7 | 20 | 40.13 | 7.59 | 47.72 | 50.414 | -0.320 | 50.400 | -0.320 | NP | 28 |
| 1 | TD | 8 | 20 | 47.28 | 9.2 | 56.48 | 50.395 | -0.311 | 50.413 | -0.309 | NP | 28 |
| 1 | TD | 9 | 20 | 60.47 | 23.17 | 83.64 | 50.410 | -0.298 | 50.388 | -0.290 | NP | 28 |
| 1 | TD | 10 | 20 | 48.51 | 9.77 | 58.28 | 50.395 | -0.318 | 50.411 | -0.315 | NP | 28 |
| 1 | TD | 11 | 30 | 107.08 | 23.36 | 130.44 | 50.420 | -0.309 | 50.443 | -0.315 | NP | 28 |
| 1 | TD | 12 | 30 | 107.01 | 22.98 | 129.99 | 50.440 | -0.312 | 50.415 | -0.304 | NP | 28 |
| 1 | TD | 13 | 30 | 77.04 | 26.45 | 103.49 | 50.415 | -0.294 | 50.438 | -0.300 | NP | 28 |
| 2 | TD | 14 | 10 | 95.79 | 41.42 | 137.21 | 50.405 | -0.060 | 50.393 | -0.055 | NP | 28 |
| 2 | TD | 15 | 10 | 44.58 | 57.54 | 102.12 | 50.391 | -0.059 | 50.398 | -0.066 | NP | 28 |
| 2 | TD | 16 | 10 | 47.46 | 63.13 | 110.59 | 50.403 | -0.059 | 50.413 | -0.064 | NP | 28 |
| 2 | TD | 17 | 15 | 81.92 | 92.83 | 174.75 | 50.415 | -0.056 | 50.402 | -0.048 | NP | 28 |
| 2 | TD | 18 | 15 | 95.61 | 112.65 | 208.26 | 50.397 | -0.029 | 50.411 | -0.039 | NP | 28 |
| 2 | TD | 19 | 15 | 55.47 | 85.98 | 141.45 | 50.408 | -0.073 | 50.395 | -0.078 | NP | 28 |
| 2 | TD | 20 | 20 | 101.67 | 137.92 | 239.59 | 50.390 | -0.089 | 50.405 | -0.087 | NP | 28 |
| 2 | TD | 21 | 20 | 51.92 | 82.08 | 134.00 | 50.415 | -0.075 | 50.397 | -0.078 | NP | 28 |
| 2 | TD | 22 | 20 | 109.29 | 160.94 | 270.23 | 50.395 | -0.067 | 50.400 | -0.035 | NP | 28 |
| 2 | TD | 23 | 30 | 104.83 | 148.43 | 253.26 | 50.398 | -0.028 | 50.422 | -0.032 | NP | 28 |
| 2 | TD | 24 | 30 | 106.78 | 103.14 | 209.92 | 50.418 | -0.063 | 50.429 | -0.031 | NP | 28 |
| 2 | TD | 25 | 30 | 110.74 | 105.82 | 216.56 | 50.417 | -0.050 | 50.431 | -0.011 | NP | 28 |
| 3 | SG | 26 | 20 | 82.75 | 39.94 | 122.69 | 50.453 | 0.208 | 50.466 | 0.206 | NP | 28 |
| 3 | SG | 27 | 20 | 73.5 | 24.33 | 97.83 | 50.470 | 0.212 | 50.458 | 0.214 | NP | 28 |
| 3 | SG | 28 | 20 | 97.59 | 44.33 | 141.92 | 50.454 | 0.228 | 50.466 | 0.224 | NP | 34 |
| 3 | SG | 29 | 20 | 98.27 | 35.07 | 133.34 | 50.472 | 0.231 | 50.460 | 0.235 | A | 34 |
| 3 | SG | 30 | 20 | 78.02 | 41.96 | 119.98 | 50.458 | 0.247 | 50.471 | 0.243 | B | 34 |
| 3 | SG | 31 | 20 | 116.92 | 69.48 | 186.40 | 50.471 | 0.242 | 50.458 | 0.246 | B | 34 |
| 3 | SG | 32 | 20 | 102.01 | 36.11 | 138.12 | 50.461 | 0.234 | 50.472 | 0.231 | A | 34 |
| 4 | SG | 33 | 20 | 42.15 | 2.97 | 45.12 | 50.527 | 0.555 | 50.543 | 0.554 | NP | 34 |
| 4 | SG | 34 | 20 | 78.75 | 4.37 | 83.12 | 50.557 | 0.558 | 50.540 | 0.585 | NP | 34 |
| 4 | SG | 35 | 20 | 60.79 | 2.48 | 63.27 | 50.528 | 0.584 | 50.517 | 0.602 | NP | 34 |
| 4 | SG | 36 | 20 | 39.44 | 1.33 | 40.77 | 50.532 | 0.600 | 50.548 | 0.586 | NP | 34 |
| 4 | SG | 37 | 20 | 109.19 | 4.18 | 113.37 | 50.551 | 0.590 | 50.564 | 0.618 | C | 34 |
| 4 | SG | 38 | 20 | 116.54 | 5.76 | 122.30 | 50.548 | 0.578 | 50.561 | 0.610 | C | 34 |
| 4 | SG | 39 | 20 | 77.74 | 2.82 | 80.56 | 50.545 | 0.587 | 50.556 | 0.612 | C | 34 |
| 5 | SG | 40 | 20 | 49.88 | 1.35 | 51.23 | 50.571 | 0.906 | 50.556 | 0.921 | NP | 34 |
| 5 | SG | 41 | 20 | 76.82 | 0 | 76.82 | 50.549 | 0.927 | 50.568 | 0.936 | NP | 34 |
| 5 | SG | 42 | 20 | 31.88 | 0.55 | 32.43 | 50.595 | 0.922 | 50.612 | 0.907 | NP | 34 |
| 5 | SG | 43 | 20 | 19.08 | 0.7 | 19.78 | 50.618 | 0.889 | 50.647 | 0.855 | NP | 34 |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 5 | SG | 44 | 20 | 19.2 | 0 | 19.20 | 50.608 | 0.807 | 50.615 | 0.789 | NP | 34 |
| 5 | SG | 45 | 20 | 28.41 | 0.2 | 28.61 | 50.623 | 0.779 | 50.633 | 0.751 | NP | 34 |
| 5 | SG | 46 | 20 | 27.93 | 0.89 | 28.82 | 50.625 | 0.753 | 50.620 | 0.774 | NP | 34 |
| 6 | SG | 47 | 20 | 111.85 | 8.16 | 120.01 | 50.517 | 0.149 | 50.516 | 0.128 | NP | 34 |
| 6 | SG | 48 | 20 | 81.71 | 7.93 | 89.64 | 50.515 | 0.123 | 50.515 | 0.156 | D | 34 |
| 6 | SG | 49 | 20 | 73.49 | 6.84 | 80.33 | 50.519 | 0.156 | 50.530 | 0.146 | NP | 34 |
| 6 | SG | 50 | 20 | 37.04 | 3.87 | 40.91 | 50.524 | 0.144 | 50.515 | 0.137 | NP | 34 |
| 6 | SG | 51 | 20 | 48.85 | 3.89 | 52.74 | 50.517 | 0.130 | 50.523 | 0.150 | E | 34 |
| 6 | SG | 52 | 20 | 60.13 | 6.13 | 66.26 | 50.523 | 0.149 | 50.518 | 0.129 | E | 34 |
| 6 | SG | 53 | 20 | 52.08 | 4.75 | 56.83 | 50.515 | 0.129 | 50.518 | 0.149 | D | 34 |
| 7 | SG | 54 | 20 | 33.45 | 11.79 | 45.24 | 50.537 | -0.135 | 50.550 | -0.142 | NP | 34 |
| 7 | SG | 55 | 20 | 33.48 | 11.01 | 44.49 | 50.548 | -0.147 | 50.533 | -0.146 | NP | 34 |
| 7 | SG | 56 | 20 | 26.93 | 14.67 | 41.60 | 50.525 | -0.149 | 50.538 | -0.155 | NP | 34 |
| 7 | SG | 57 | 20 | 28.76 | 16.05 | 44.81 | 50.540 | -0.162 | 50.555 | -0.168 | F | 34 |
| 7 | SG | 58 | 20 | 46.39 | 19.39 | 65.78 | 50.551 | -0.173 | 50.531 | -0.168 | G | 34 |
| 7 | SG | 59 | 20 | 51.02 | 21.5 | 72.52 | 50.528 | -0.168 | 50.545 | -0.179 | G | 34 |
| 7 | SG | 60 | 20 | 38.82 | 23.98 | 62.80 | 50.538 | -0.157 | 50.517 | -0.148 | F | 34 |
| 8 | SG | 61 | 20 | 82.24 | 8.37 | 90.61 | 50.559 | -0.469 | 50.545 | -0.474 | NP | 34 |
| 8 | SG | 62 | 20 | 64.51 | 9.76 | 74.27 | 50.535 | -0.475 | 50.523 | -0.484 | H | 34 |
| 8 | SG | 63 | 20 | 38.44 | 3.77 | 42.21 | 50.537 | -0.478 | 50.550 | -0.477 | NP | 34 |
| 8 | SG | 64 | 20 | 80.78 | 5.61 | 86.39 | 50.546 | -0.471 | 50.529 | -0.462 | G | 34 |
| 8 | SG | 65 | 20 | 57.29 | 8.24 | 65.53 | 50.529 | -0.466 | 50.548 | -0.452 | NP | 34 |
| 8 | SG | 66 | 20 | 60.79 | 6.84 | 67.63 | 50.543 | -0.467 | 50.526 | -0.457 | G | 34 |
| 8 | SG | 67 | 20 | 98.51 | 14.37 | 112.88 | 50.518 | -0.475 | 50.522 | -0.494 | H | 34 |
| 9 | SG | 68 | 20 | 46.18 | 57.82 | 104.00 | 50.243 | -0.160 | 50.269 | -0.134 | NP | 34 |
| 9 | SG | 69 | 20 | 42.36 | 41.08 | 83.44 | 50.254 | -0.120 | 50.250 | -0.102 | NP | 34 |
| 9 | SG | 70 | 20 | 61.67 | 76.6 | 138.27 | 50.236 | -0.071 | 50.233 | -0.050 | NP | 34 |
| 9 | SG | 71 | 20 | 110.01 | 212.06 | 322.07 | 50.258 | -0.046 | 50.268 | -0.047 | I | 34 |
| 9 | SG | 72 | 20 | 98.27 | 266.28 | 364.55 | 50.267 | -0.033 | 50.253 | -0.032 | J | 34 |
| 9 | SG | 73 | 20 | 81.27 | 207.26 | 288.53 | 50.259 | -0.035 | 50.269 | -0.035 | J | 34 |
| 9 | SG | 74 | 20 | 124.3 | 119.01 | 243.31 | 50.268 | -0.054 | 50.257 | -0.051 | J | 34 |
| 9 | D | 75 | 20 | 82.94 | 202.46 | 285.40 | 50.251 | -0.047 | 50.269 | -0.047 | I | 34 |
| 9 | D | 76 | 20 | 65.07 | 163.49 | 228.56 | 50.266 | -0.048 | 50.253 | -0.047 | NP | 34 |
| 9 | D | 77 | 20 | 89.19 | 206.83 | 296.02 | 50.254 | -0.048 | 50.269 | -0.049 | NP | 34 |
| 9 | D | 78 | 20 | 76.79 | 193.45 | 270.24 | 50.266 | -0.052 | 50.252 | -0.047 | NP | 34 |
| 9 | D | 79 | 20 | 67.91 | 137.24 | 205.15 | 50.254 | -0.055 | 50.267 | -0.047 | NP | 34 |
| 9 | D | 80 | 20 | 89.9 | 199.18 | 289.08 | 50.266 | -0.056 | 50.252 | -0.047 | NP | 34 |
| 9 | D | 81 | 20 | 72.79 | 161.91 | 234.70 | 50.250 | -0.050 | 50.265 | -0.044 | NP | 34 |
| 10 | SG | 82 | 20 | 35.71 | 31.3 | 67.01 | 50.410 | 0.258 | 50.423 | 0.256 | NP | 34 |
| 10 | SG | 83 | 20 | 32.04 | 15.08 | 47.12 | 50.424 | 0.240 | 50.410 | 0.241 | K | 34 |
| 10 | SG | 84 | 20 | 36.66 | 30.66 | 67.32 | 50.407 | 0.246 | 50.421 | 0.244 | NP | 34 |
| 10 | SG | 85 | 20 | 41.15 | 15.3 | 56.45 | 50.428 | 0.245 | 50.415 | 0.250 | L | 34 |
| 10 | SG | 86 | 20 | 36.69 | 13.4 | 50.09 | 50.411 | 0.265 | 50.426 | 0.261 | NP | 34 |
| 10 | SG | 87 | 20 | 47.13 | 15.35 | 62.48 | 50.429 | 0.247 | 50.417 | 0.251 | L | 34 |
| 10 | SG | 88 | 20 | 54 | 26.6 | 80.60 | 50.413 | 0.245 | 50.425 | 0.239 | K | 34 |
| 11 | SG | 89 | 20 | 27.28 | 8.29 | 35.57 | 50.447 | 0.380 | 50.460 | 0.379 | NP | 34 |
| 11 | SG | 90 | 20 | 55.27 | 4.85 | 60.12 | 50.465 | 0.418 | 50.484 | 0.418 | NP | 34 |
| 11 | SG | 91 | 20 | 69.22 | 5.96 | 75.18 | 50.508 | 0.424 | 50.530 | 0.409 | NP | 34 |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 11 | SG | 92 | 20 | 74.98 | 5.65 | 80.63 | 50.535 | 0.410 | 50.520 | 0.393 | NP | 34 |
| 11 | SG | 93 | 20 | 57.76 | 4.09 | 61.85 | 50.527 | 0.394 | 50.536 | 0.416 | NP | 34 |
| 11 | SG | 94 | 20 | 46.74 | 1.98 | 48.72 | 50.539 | 0.414 | 50.520 | 0.397 | NP | 34 |
| 11 | SG | 95 | 20 | 117.29 | 5.34 | 122.63 | 50.526 | 0.411 | 50.535 | 0.426 | NP | 34 |
| 4 | D | 96 | 20 | 77.34 | 3.56 | 80.90 | 50.550 | 0.585 | 50.559 | 0.606 | NP | 34 |
| 4 | D | 97 | 20 | 80.3 | 7.23 | 87.53 | 50.563 | 0.614 | 50.553 | 0.586 | NP | 34 |
| 4 | D | 98 | 20 | 79.77 | 2.13 | 81.90 | 50.547 | 0.576 | 50.557 | 0.599 | NP | 34 |
| 4 | D | 99 | 20 | 90.53 | 2.89 | 93.42 | 50.564 | 0.645 | 50.554 | 0.594 | NP | 34 |
| 4 | D | 100 | 20 | 94.83 | 4.32 | 99.15 | 50.550 | 0.586 | 50.563 | 0.611 | NP | 34 |
| 4 | D | 101 | 20 | 109.47 | 5.88 | 115.35 | 50.564 | 0.614 | 50.564 | 0.582 | NP | 34 |
| 4 | D | 102 | 20 | 83.42 | 7.9 | 91.32 | 50.563 | 0.584 | 50.562 | 0.623 | NP | 34 |
| 12 | SG | 103 | 20 | 117.14 | 34.28 | 151.42 | 50.418 | 0.085 | 50.404 | 0.081 | NP | 34 |
| 12 | SG | 104 | 20 | 148.92 | 66.8 | 215.72 | 50.400 | 0.071 | 50.384 | 0.074 | M | 34 |
| 12 | SG | 105 | 20 | 99.24 | 69.38 | 168.62 | 50.384 | 0.081 | 50.395 | 0.089 | N | 34 |
| 12 | SG | 106 | 20 | 110.64 | 28.35 | 138.99 | 50.402 | 0.096 | 50.417 | 0.102 | NP | 34 |
| 12 | SG | 107 | 20 | 102.85 | 31.95 | 134.80 | 50.423 | 0.085 | 50.409 | 0.073 | NP | 34 |
| 12 | SG | 108 | 20 | 136.4 | 49.91 | 186.31 | 50.402 | 0.069 | 50.387 | 0.072 | M | 34 |
| 12 | SG | 109 | 20 | 82.73 | 58.81 | 141.54 | 50.385 | 0.082 | 50.397 | 0.090 | N | 34 |
| 13 | SG | 110 | 20 | 35.28 | 26.01 | 61.29 | 50.395 | -0.203 | 50.411 | -0.199 | O | 34 |
| 13 | SG | 111 | 20 | 45.64 | 23.72 | 69.36 | 50.416 | -0.208 | 50.406 | -0.216 | NP | 34 |
| 13 | SG | 112 | 20 | 54.56 | 25.04 | 79.60 | 50.414 | -0.238 | 50.402 | -0.237 | NP | 34 |
| 13 | SG | 113 | 20 | 23.87 | 6.83 | 30.70 | 50.400 | -0.249 | 50.389 | -0.247 | NP | 34 |
| 13 | SG | 114 | 20 | 37.47 | 14.97 | 52.44 | 50.391 | -0.238 | 50.407 | -0.227 | NP | 34 |
| 13 | SG | 115 | 20 | 49.54 | 34.43 | 83.97 | 50.395 | -0.202 | 50.411 | -0.198 | O | 34 |
| 13 | SG | 116 | 20 | 79.1 | 41.97 | 121.07 | 50.416 | -0.198 | 50.396 | -0.193 | O | 34 |
| 14 | SG | 117 | 20 | 77.65 | 65.14 | 142.79 | 50.338 | -0.088 | 50.354 | -0.086 | P | 34 |
| 14 | SG | 118 | 20 | 95.63 | 76.67 | 172.30 | 50.356 | -0.084 | 50.341 | -0.071 | NP | 34 |
| 14 | SG | 119 | 20 | 107.9 | 63.42 | 171.32 | 50.346 | -0.072 | 50.362 | -0.072 | NP | 34 |
| 14 | SG | 120 | 20 | 58.65 | 64.25 | 122.90 | 50.364 | -0.087 | 50.347 | -0.100 | NP | 34 |
| 14 | SG | 121 | 20 | 90.68 | 75.74 | 166.42 | 50.337 | -0.109 | 50.319 | -0.125 | Q | 34 |
| 14 | SG | 122 | 20 | 113.16 | 42.35 | 155.51 | 50.315 | -0.128 | 50.331 | -0.110 | Q | 34 |
| 14 | SG | 123 | 20 | 88.28 | 52.41 | 140.69 | 50.340 | -0.100 | 50.351 | -0.080 | P | 34 |
| 15 | SG | 124 | 20 | 128.01 | 96.71 | 224.72 | 50.307 | 0.136 | 50.292 | 0.153 | NP | 34 |
| 15 | SG | 125 | 20 | 70.46 | 81.25 | 151.71 | 50.295 | 0.139 | 50.285 | 0.144 | R | 34 |
| 15 | SG | 126 | 20 | 98.23 | 50.97 | 149.20 | 50.278 | 0.143 | 50.266 | 0.146 | NP | 34 |
| 15 | SG | 127 | 20 | 72.72 | 57.19 | 129.91 | 50.267 | 0.150 | 50.281 | 0.151 | NP | 34 |
| 15 | SG | 128 | 20 | 103.41 | 144.5 | 247.91 | 50.286 | 0.141 | 50.295 | 0.125 | S | 34 |
| 15 | SG | 129 | 20 | 89.93 | 55.85 | 145.78 | 50.301 | 0.116 | 50.287 | 0.118 | S | 34 |
| 15 | SG | 130 | 20 | 83.6 | 77.36 | 160.96 | 50.282 | 0.157 | 50.291 | 0.142 | R | 34 |
| 16 | SG | 131 | 20 | 53.82 | 17.84 | 71.66 | 50.491 | 0.049 | 50.503 | 0.041 | NP | 34 |
| 16 | SG | 132 | 20 | 104.37 | 26.07 | 130.44 | 50.504 | 0.034 | 50.488 | 0.030 | T | 34 |
| 16 | SG | 133 | 20 | 79.04 | 29.07 | 108.11 | 50.487 | 0.042 | 50.504 | 0.036 | NP | 34 |
| 16 | SG | 134 | 20 | 114.05 | 35.47 | 149.52 | 50.502 | 0.027 | 50.485 | 0.026 | U | 34 |
| 16 | SG | 135 | 20 | 115.06 | 25.45 | 140.51 | 50.485 | 0.035 | 50.499 | 0.035 | NP | 34 |
| 16 | SG | 136 | 20 | 103.07 | 34.96 | 138.03 | 50.503 | 0.025 | 50.488 | 0.025 | U | 34 |
| 16 | SG | 137 | 20 | 125.57 | 37.44 | 163.01 | 50.487 | 0.029 | 50.504 | 0.034 | T | 34 |

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