Industrial survey for associ-ated species: Results of a pilot-year

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Samenvatting

Vispopulaties worden beheerd met verschillende regelgeving. Een voorbeeld hierin is de Europese Unie-gereguleerde Totaal Toegestane Vangst (TAC). Deze TACs worden vastgesteld door de minsterraad. De raad gebruikt hierbij het vangst advies van de Internationale Raad voor Onderzoek der Zee (ICES). Het vangst advies is gebaseerd op bestandsschattingen, welke commerciële aanlandgegevens combineren met de resultaten van wetenschappelijke surveys. De nauwkeurigheid en betrouwbaarheid van de bestandsschattingen hangt af van de kwaliteit en betrouwbaarheid van de aangeleverde gegevens. Voor een aantal vissoorten is er niet voldoende informatie beschikbaar om een volledige bestandsschatting uit te voeren, waarbij de totale paaibiomassa en de visserijmortaliteit worden geschat. Het vangstadvies voor deze vissoorten wordt gebaseerd op de “data-gelimiteerde soorten methode”. Deze methode gebruikt in het algemeen de gemiddelde vangst per visserijinspanning (CpUE, in kg/kWzeedagen) van één of meerdere wetenschappelijke onderzoekssurveys waarop voorzorgsmaatregelen worden toegepast. Voor sommige soorten is de trend in CpUE zeer onbetrouwbaar, veroorzaakt door lage vangsten, waardoor er een gebrek is in wetenschappelijke kennis over populatie trends.

Het commerciële visserijbedrijf Ekofish Group B.V. heeft IMARES gevraagd een bedrijfssurvey te ontwerpen, met als doel het verzamelen van wetenschappelijke betrouwbare CpUEs van tarbot (*Scopthalmus maximus*), griet (*Scopthalmus rhombus*) en tongschar (*Microstomus kitt*). In 2014 werd een pilot-survey uitgevoerd om de praktische haalbaarheid en wetenschappelijke toegevoegde waarde van een dergelijke bedrijfssurvey vast te stellen. Hiervoor werden de resultaten vergeleken met de gegevens van de wetenschappelijke Boomkor survey (BTS). Oorspronkelijk is de BTS opgericht om een goed beeld te krijgen van veranderingen in de populaties van schol en tong. Aan boord worden echter alle gevangen organismen gedetermineerd, geteld (voor vissen per lengteklasse) en geregistreerd. De BTS wordt hierdoor nu gebruikt als dé wetenschappelijke survey voor platvissen.

De pilot-survey werd uitgevoerd in kwartaal drie van 2014 aan boord van de twinrigger PD147 “Enterprise”, een schip van het vissersbedrijf Ekofish. Een totaal van 24 trekken werd uitgevoerd, verspreid over 24 ICES kwadranten. Om de effecten van trekduur op de CpUE te bepalen, werd een experimentele opzet gebruikt waarin 50% van de trekken twee uur duurde en de andere helft 3 uur. Om de effecten van maaswijdte op de CpUE te bepalen werden alle trekken uitgevoerd met een maaswijdte van 100mm aan stuurboordzijde en een maaswijdte van 120mm aan bakboordzijde. Gedurende de survey werden alle gevangen tarbot, griet en tongschar op lengte gemeten en otolieten verzameld voor leeftijd determinatie.

De resultaten van de bedrijfssurvey geven aan dat de tarbot en griet vangsten vooral geconcentreerd waren in het zuidoostelijk gedeelte van het bemonsteringsgebied, terwijl tongschar voornamelijk geconcentreerd was in het noordwesten. De kleinere maaswijdte resulteerde in een hoger aantal tongschar per trek, maar maaswijdte bleek geen significant effect te hebben op de gemiddelde lengte van de tongschar. Voor tarbot en griet waren zowel de totale aantallen als de gemiddelde lengte niet verschillend tussen de twee gebruikte maaswijdtes. Trekduur had geen significant effect op de totaalvangst en vangst efficiëntie voor alle soorten.

Uit vergelijkingen met de BTS gegevens bleek dat tongschar in soortgelijke aantallen, maar over een andere lengte-range werd gevangen, waarbij de bedrijfssurvey gemiddeld grotere individuen ving. Het verschil in de lengte-ranges kwam niet tot uiting in de leeftijdsrange van tongschar (leeftijden 2-18), al waren er kleine verschillen zichtbaar in de aantallen per leeftijd. Tarbot- en grietvangsten zijn zeer laag in de BTS, terwijl de bedrijfssurvey vangsten substantieel hoger zijn. De informatie over de lengteverdeling is daarom groter in de bedrijfssurvey gegevens. Wanneer leeftijdsverdelingen worden berekend voor beide surveys blijkt dat de waargenomen leeftijdsranges van tarbot en griet groter zijn in de bedrijfssurvey.

Samengevat heeft deze pilot-survey bewezen dat een bedrijfssurvey gericht op tongschar, tarbot en griet praktisch uitvoerbaar is. Echter, vergeleken met de BTS verschilt de toegevoegde wetenschappelijke waarde per soort: voor tarbot en griet heeft de bedrijfssurvey substantiële hogere vangsten dan de BTS, mogelijk met toegevoegde waarde voor een bestandsschatting over de veranderingen in de populatie. Voor tongschar is er een veel kleinere winst in kennis te verwachten van een bedrijfssurvey, omdat de BTS al substantieel grote vangsten heeft. IMARES raadt aan dat een vervolg op deze pilot-survey wordt uitgevoerd om de biologische kennis van tarbot en griet te vergroten. De vervolg survey kan dan worden toegespitst op tarbot en griet, met een kleine aanpassing in bemonsteringsgebied en met gestandaardiseerde trekduur en maaswijdte.

Summary

Fish stocks are managed with different measures. One of them is the European Union-regulated Total Allowable Catches (TACs). The TACs are decided by the Council of Ministers. This council takes the catch advice by the International Council for the Exploration of the Sea (ICES) into account when deciding upon TACs. The catch advice is based on stock assessments, which use commercial landings data combined with scientific survey results. The accuracy and precision of the stock assessments depend on data availability and certainty. For a number of species there is not sufficient data available to perform a full stock assessment in which the spawning stock biomass and fishing mortality are estimated. The advice for these fish stocks is therefore based on a “data-limited species approach”. This approach generally uses trends in mean Catch per Unit Effort (CpUE, in kg/kWdays) from one or more scientific research vessel surveys, and is subject to precautionary measures. For several species, the trends in CpUE are very uncertain, caused by low catchabilities. As such there is a lack of knowledge on the trends in stock abundances for several species caused by a deficiency in scientific survey data.

The commercial fishing company Ekofish Group B.V. requested IMARES to design an industrial survey, with the aim of collecting scientific accurate CpUEs of turbot (*Scopthalmus maximus*), brill (*Scopthalmus rhombus*) and lemon sole (*Microstomus kitt*). In 2014, a pilot-survey was performed to test feasibility and knowledge gain of such an industrial survey. The data were compared with the data collected within the scientific “Beam Trawl Survey” (BTS) to examine the added value of an industrial survey. Originally the BTS was started to observe trends in the populations of plaice (*Pleuronectes platessa*) and sole (*Solea solea*). However, all organisms caught within the BTS are determined, counted (for fishes per length class) and registered. The BTS is therefore nowadays used as the scientific survey for flatfishes.

The pilot survey was conducted in quarter three in 2014 on board the otter trawler PD147 “Enterprise”, a vessel owned by the fishing company Ekofish group. A total of 24 hauls were carried out in the centre of the North Sea, divided over 24 ICES rectangles. In order to test for the effect of haul duration on CpUE an experimental setup was chosen in which 50% of the hauls lasted two hours and the other 50% lasted three hours. Furthermore, to test for the effect of mesh size on CPUE, an experimental setup was chosen in which all hauls were performed with a mesh size of 100mm on starboard side and 120mm on portside. During the survey, all turbot, brill and lemon sole individuals caught were length-measured and otoliths were collected for age-determination.

Results from the industrial survey indicate that turbot and brill catches were concentrated in the south-east part of the sampling area, while lemon sole was concentrated in the northwest. The smaller mesh size resulted in a higher total number of lemon sole per haul, but the smaller mesh size did not significantly affect the average length of the lemon soles. No effects of mesh size were observed for turbot and brill. Haul duration had no significant effect on catch and catch efficiency for any of the species.

Comparisons with the BTS revealed that lemon sole was caught in similar numbers, but over a different length range, with the industrial survey catching on average larger individuals. This difference in length distribution was not reflected in the age ranges of lemon sole (age 2-18), but small differences in total numbers at age could be observed. Turbot and brill catches were very low in the BTS, while in the industrial survey the catches are substantially higher. Therefore, more information can be subtracted from the length distributions of the industrial survey. When numbers at age are calculated and compared between both surveys, the observed age ranges for turbot and brill are larger in the industrial survey.

In conclusion, this pilot-survey has proven that an industrial survey aimed for lemon sole, turbot and brill is practically feasible. However, compared with the BTS, the knowledge gain differs per species: for turbot and brill the industrial survey had substantially larger catches than the BTS survey, potentially add-

ing much information to a stock assessment on the development of the stock abundance. For lemon sole there is a smaller gain in knowledge expected from the industrial survey, because the BTS survey already catches substantial amounts of fish. IMARES recommends that a follow-up of this survey is conducted to increase biological knowledge on turbot and brill. The sequel survey could then be re-designed in favour of turbot and brill, with a small transition in sampling area and with a standardised haul duration and mesh size.

1. Introduction

1.1. Background

Commercial fisheries are structured by multiple regulations, directed at maintaining sustainable fisheries and healthy fish populations. Examples are restrictions in mesh sizes or engine power in certain areas or a maximum in fisheries effort. Besides these legal obligations, fishing companies can choose to certify their fish products by organisations like the Marine Stewardship Council (MSC). In order to obtain MSC-certification, fishing companies have to comply with the organisation-specific conditions. The MSC conditions may in cases be more strict than legal regulations for a fishery. MSC-conditions can be difficult to comply with, for instance when data about the stock status is scarce.

Ekofish Group B.V. is a commercial fishing company targeting plaice with large mesh sized otter trawlers. It was the first fishing company in the Netherlands with a MSC-certificate for plaice (*Pleuronectes platessa*). Their aim is to get MSC-certification for all species caught during their fisheries for plaice, including species with little information on stock status.

1.2. Stock assessments

The European Union (EU) has imposed Total Allowable Catches (TACs) per member state for a number of species in the North Sea. In general, TACs are calculated based on spawning stock biomass, which is calculated in stock assessments. For many species in the North Sea, the International Council for Exploration of the Sea (ICES) is performing stock assessments. To assess a fish population, all commercial landings (in numbers at age), discards (in numbers at age) and the fishing effort should be known. With these numbers, fishing mortality can be calculated and total biomass of a population can be calculated retrospectively.

However, commercial landings per unit effort do not always reflect population trends as fisheries are constant developing new, more efficient fishing methods. Stable landings per unit effort could thus be the result of a decreasing population with more efficient fishers. Therefore, scientific surveys are performed and taken into account in stock assessments. During a scientific survey, fishing effort is constant over the years, as the fishing gear, speed and locations are kept constant. Relative differences between years in catches of a scientific survey represent relative differences in the fish population. Stock assessments combine both the commercial catch (summation of landings and discards) per unit effort data and the scientific surveys.

The scientific Beam Trawl Survey (BTS) provides information for flatfish species in the North Sea. This survey is performed each year in the third quarter covering the central and southern part of the North Sea. Originally the BTS was designed to catch sole (*Solea solea*) and plaice, but all species caught are registered. As not all species are caught frequently by the BTS because the survey was not designed for these species, this may result in data limitations for the stock assessment of certain species.

1.3. Data-limited species

Depending on the (international) data input and importance of the species, the type of model that is used to assess population biomass varies. For target species like plaice much data is available, in both commercial landings, discards and in scientific surveys. Therefore, accurate and descriptive assessment models can be run for such species. Species with high unregistered discards, low landings by commercial fisheries or otherwise insufficient data, on the other hand, cannot have accurate and descriptive models. These species are classified as data-limited species by ICES. A survey trends based assessment model is developed by ICES to deal with such data-limited stocks. This model is indicative of trends in population biomass, but does not calculate actual biomass. To compensate for inaccuracy of these models, strict precautionary measures are in place for these species.

Brill (*Scopthalmus rhombus*), turbot (*Scopthalmus maximus*) and lemon sole (*Microstomus kitt*) are species classified as data-limited by ICES. For these species, a survey trends based assessment is performed and no proper management is in place. Consequently, it is impossible to comply with MSC-conditions for these species.

1.4. Industrial survey

To increase scientific knowledge and stimulate discussion on management of data-limited species, Ekofish Group B.V., the North Sea Foundation (NSF) and IMARES started a research project. This project consisted of two phases. In the first phase, IMARES and NSF performed a literature study on the constrains in management and biological knowledge for species selected by Ekofish (Doeksen and van der Reijden, 2014). The conclusion of this phase was that good fisheries management ultimately relies on complete and reliable information about fishery and fish stock dynamics and interactions. At present, this remains a weakness in the management of brill and turbot. For lemon sole, the conclusion was that the BTS probably contained enough data for lemon sole to perform a stock assessment. However, for lemon sole, it remained unclear why no stock assessment model has ever been prepared. Until science provides more accurate information and establishes more accurate stock assessment models, these species will likely continue to be managed under a precautionary TAC, implying generally more conservative fishing opportunities.

After phase one, Ekofish Group B.V. requested IMARES to set up an industrial survey to gather more information on turbot, brill and lemon sole. A pilot-survey was designed and performed for these species to test whether an industrial survey is feasible and valuable for biological knowledge and if so, how this survey should be designed. To test the design of the survey, research will be done on the haul duration and mesh size. To examine the added value of the pilot survey, results are compared with the BTS. In this report, the results of this pilot survey are presented and answer will be given to the following research question: "*Is an industrial survey for turbot, bill and lemon sole feasible and does it increase knowledge with respect to scientific surveys?"*

2. Materials and Methods

2.1. Survey design

2.1.1. Vessel selection, fishing location and sampling period

As Ekofish was partner in this project, they delivered the participating ship; the PD147 "Enterprise". This English vessel (44.9m * 9.4m; 2514 hp; built in 1995) is an otter trawler. Survey sampling area was determined based on:

1. Ekofish group fishing locations
2. The average spatial distribution of the Landings per Unit Effort (LpUE) for turbot and brill in the total beam trawl fleet in 2004-2010 (Hammen et al. 2013)
3. The spatial distribution of all three species in catches per hour in the BTS in 2013 (Boois et al. 2013)

This resulted in a sampling area of 24 ICES rectangles in the central part of the North Sea (figure 1). Each rectangle was sampled once, with the starting point in the middle of the rectangle. To be able to compare catch rates of this survey with the BTS catches, the sampling period was kept as similar as possible to the BTS. The survey took place during weekdays of weeks 38-40 in 2014 (September 15th – October 3rd).

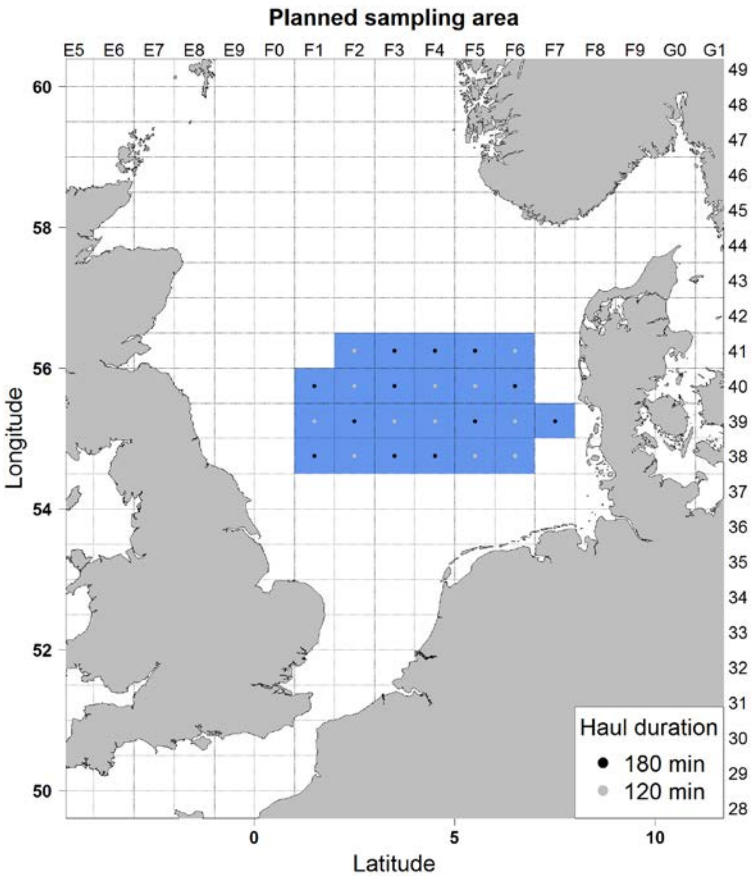


***Figure 1**. The scheduled sampling locations with corresponding haul duration.*

2.1.2. Haul duration and gear used

In this pilot-year, the design of the survey was tested for the effect of mesh size and haul duration on the catch. With this information, a follow up of this survey could be designed to the best knowledge. Catch rates were expected to be low, since the survey was aiming to collect data off bycatch species. Therefore, a trade-off exists between longer haul duration (more fish, less hauls, less hauling time) and shorter haul duration (less fish, more hauls, more hauling time). To test for the effects of haul duration, halve of the hauls (i.e. 12 hauls) were randomly selected and assigned a haul duration of three hours (180 min). The remaining (12) hauls were assigned a duration of 2 hours (120 min) (figure 1).

The PD147 “Enterprise” is an otter trawler, using twinrig gear. To determine effects of mesh size on the catchability and length distribution of lemon sole, turbot and brill, the gear was deployed with a 100mm cod end on starboard side and 120mm cod end on port side. For a survey it is necessary to catch a wide range of lengths, so that many age-classes are covered. Using a smaller mesh size would increase the chance of catching smaller (and hopefully younger) fish. However, it may also cause a decrease in catch-ability of the larger fishes.

2.2. Survey measurements

2.2.1. Species of interest

This industrial survey was aimed for turbot, brill and lemon sole. However, since the catch was sorted already, it was decided in collaboration with Ekofish to collect data for more species. Species with an expected high catch rate and/or with already enough data in scientific surveys were not taken into account. This resulted in a group of species of non-interest, namely plaice, dab (*Limanda limanda*), grey gurnard (*Eutrigla gurnardus*), thorny skate (*Amblyraja radiata*) and thornback ray (*Raja clavata*). For these species, no measurements were conducted.

2.2.2. Length distribution

For both sides separately, the total length of all fish (only species of interest) was measured to the centimetre below (15.0 - 15.9 cm is length class 15). This resulted in total numbers per length class. For the length-measured skates and sharks sex was registered as well. When large quantities of a certain species were encountered, a subsample was taken.

2.2.3. Age determination

After each haul, otoliths of turbot, brill and lemon sole were sampled. To ensure an accurate age-length relation, three fishes per length class were taken from each haul. These fishes were first sexed and length was measured in mm. Then otoliths were removed, stored and processed in the lab, which resulted in an age determination of each individual.

2.3. Analysis

Data management software was used to enter and audit all data before the data were stored in the centralised IMARES database. All data was analysed using R (R Development Core Team 2005).

2.3.1. Effects of survey design

The effect of mesh size on total number and average length was tested using a paired T-test, corrected for differences in variance. The effects of haul duration on the total number of fish and the average number per hour was tested using an independent two-sampleT-test (Welchs t-test), corrected for differences in variance.

2.3.2. BTS

De beam trawl survey is a scientific survey aimed for sole and plaice, using a beam trawl of 8m with mesh sizes of 40mm. Haul duration is standardised at 30 minutes, after which the complete catch is determined, sorted and counted. Length measurements are made for all fish species and some commercially valuable non-fish species, like edible crab (*Cancer pagurus*), Norway lobster (*Nephrops norvegicus*) and squids. The BTS is fishing each year with a standardised fishing effort. Fishing locations, speed and gear are kept as similar as possible between years. Because of this, catches can easily be compared between years.

2.3.3. Age distribution

In order to obtain age distributions in the industrial survey, the age composition at each length class, a so-called age-length-key (ALK), first needed to be established from the age sampled fishes. This ALK was then applied to the total numbers per length class, resulting in the total numbers per age. The same ALK was also applied to the numbers per length class per rectangle, which gave the spatial distribution of the numbers per age. The same method was conducted to the BTS data to obtain age distributions and the results are visually compared to the industrial survey. As age data was not available yet for BTS 2014, we used the BTS 2013 data to calculate the age distribution.

2.3.4. Comparison with BTS catches

Length distributions of turbot, brill and lemon sole in the BTS were extracted from the IMARES database. Total numbers per length class and numbers per length class for the sampling area were visually compared with the total numbers caught in the industrial survey.

3. Results

The survey was performed almost exactly as scheduled. However, one rectangle was not sampled in the centre because of the Plaice Box restrictions (figure 2A). The sampling area was well covered by the BTS (figure 2B). During this pilot-year, the lengths of 5841 fishes were measured, spread over 24 species (table 1). In total 1326 otoliths were collected for turbot, brill and lemon sole (table 1). For all species with more than 100 individuals, a summary of the length range is given in table 1 as well.

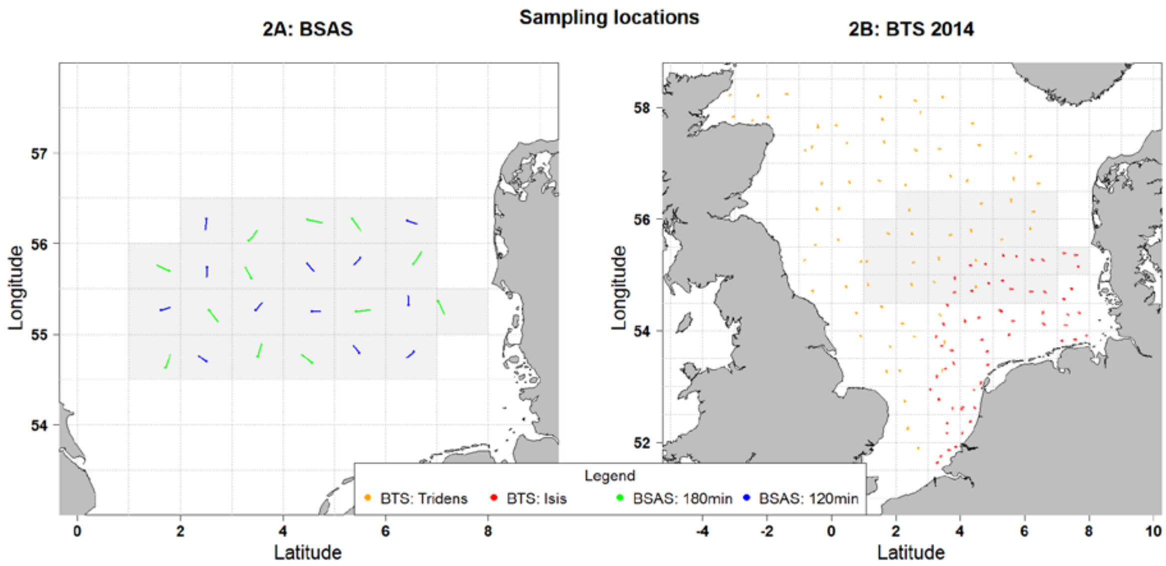


Figure 2. *Performed sampling locations for A) the industrial survey pilot-year (BSAS) and B) the BTS in 2014.Sampling area of the BSAS is displayed as the grey box.*

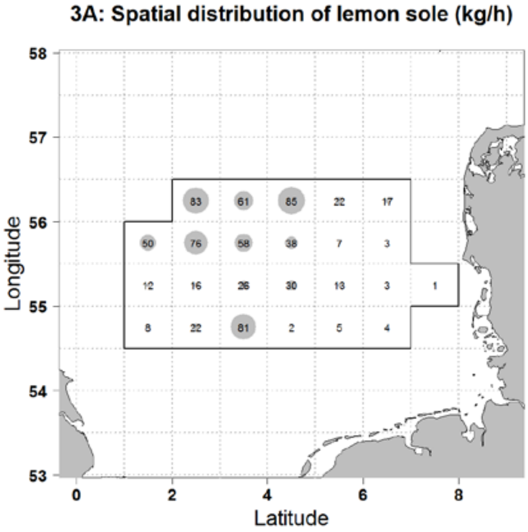
For lemon sole, turbot and brill, the spatial distribution differed between the species (figure 3). Lemon sole was concentrated in the north-western part of sampling area (figure 3A), while turbot and brill were caught more in the south-eastern part of the sampling area (figures 3B and 3C respectively). This was congruent with the information of the BTS and LpUEs.

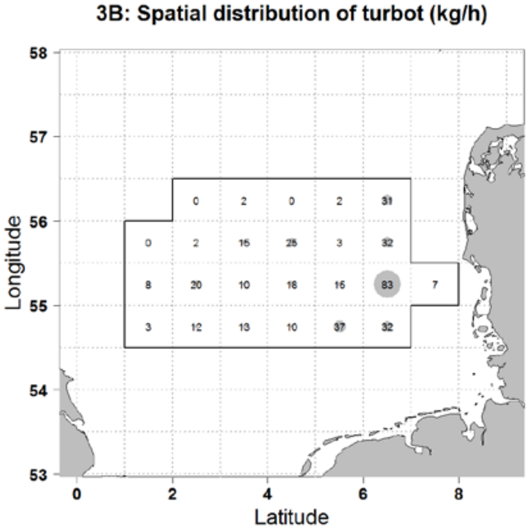
3.1 Effects of mesh size and haul duration

All 24 hauls were made with 100mm mesh size on starboard side and 120mm mesh size on port side. A paired t-test was performed to compare the total numbers of turbot, brill and lemon sole per haul and the average length (cm) of the catch per haul (table 2) for the two mesh sizes. Only for lemon sole, the total number of fish caught was significantly different between the two mesh sizes. Mesh size had no significant effect on the average length of the fish (table 2).

Table 1. *For all species of interest per species the total numbers caught, measured for length distribution and total number of otoliths collected. For shark and skate species, the numbers are displayed separately for females and (males). For species with more than 100 individuals caught, the minimum, maximum and average length is given, also females and (males) separately.*

Scientific name	**English name**	**Sample size**			**Length**		
		Caught	**Measured**	**Otoliths**	**Min**	**Max**	**Average**
Agonus cataphractus	*Hooknose*	1	1				
Anarhichas lupus	*Seawolf*	1	1				
Chelidonichthys lucerna	*Tub gurnard*	651	555		21	53	30.8
Gadus morhua	*Cod*	502	502		19	110	47.7
Glyptocephalus cynoglossus	*Witch*	1202	723		10	49	34.3
Hippoglossoides platessoides	*American plaice*	1	1				
Hippoglossus hippoglossus	*Atlantic halibut*	2	2				
Leucoraja naevus	*Cuckoo ray*	7 (1)	7 (1)				
Lophius piscatorius	*Angler fish*	99	99				
Melanogrammus aeglefinus	*Haddock*	134	134		12	48	38.3
Merlangius merlangus	*Whiting*	180	180		19	34	26.9
Merluccius merluccius	*Hake*	36	36				
Microstomus kitt	*Lemon sole*	3974	2628	851	15	43	27.1
Platichthys flesus	*Flounder*	62	62				
Pollachius virens	*Saithe*	1	1				
Raja brachyura	*Blonde ray*	1 (2)	1 (2)				
Raja montagui	*Spotted ray*	45 (28)	45 (28)				
Scomber scombrus	*Mackerel*	4	4				
Scophthalmus maximus	*Turbot*	384	384	333	21	57	37.0
Scophthalmus rhombus	*Brill*	174	174	142	23	59	32.7
Scyliorhinus canicula	*Small-spotted catshark*	8 (4)	8 (4)				
Solea solea	*Sole*	7	7				
Squalus acanthias	*Spiny dogfish*	32 (143)	32 (143)		81 (27)	130 (115)	102.0 (81.0)
Zeus faber	*John dory*	7	7				
Total		**7693**	**5772**	**1326**			





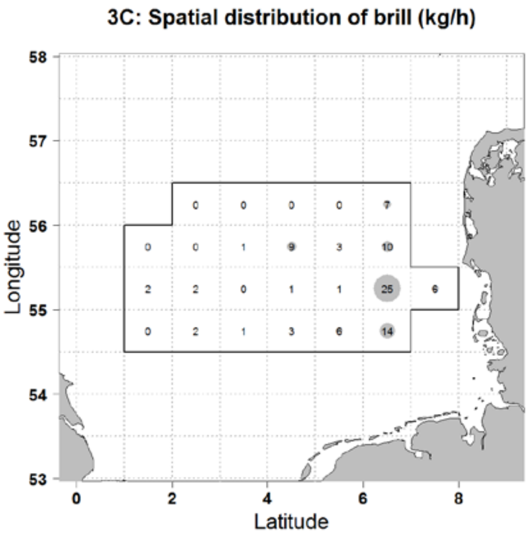


Figure 3. *Spatial distribution of the catches (in kg/h) for A) lemon sole, B) turbot and C) brill. The numbers in the rectangles are the CpUEs (in kg/h). The grey circles display relative differences in CpUEs, as the diameters of the circle represent the CpUE of that rectangle. Diameters of grey circles cannot be compared between graphs because they represent relative CpUE of that species.*

Table 2. *The effect of mesh size on total number and average length (cm) of the catch. For each species the mean of total number and average length per side, standard deviation (SD), the results of the Paired t-test and corresponding indicator of significance (S=Significant, NS=Not significant) at the significance level of 0.05 are shown. (As catches within a haul are compared, the Unit Effort per haul is similar.)*

Species		**Port side (120mm)**		**Starboard side (100 mm)**		**T-test results**			
		Mean	**SD**	**Mean**	**SD**	**t-value**	**DF**	**p-value**	**Significance**
Turbot	Total number	8.1	9.7	7.9	10.8	-0.288	23	0.776	NS
	Average length	27.8	16.8	33	15.7	1.498	23	0.148	NS
Brill	Total number	4.3	8.2	3	5	-1.691	23	0.104	NS
	Average length	21.5	19	16.3	18.5	-1.159	23	0.259	NS
Lemon sole	Total number	60	76.8	105.5	104.4	4.329	23	< 0.001	S
	Average length	27.1	6.1	27.4	1.5	0.226	23	0.823	NS

Table 3 shows the average total catch (kg) and CpUE (in kg/h) for the 180min hauls and the 120min hauls. Although differences can be observed between the average catches between longer and shorter hauls (table 3: “180m mean” and “120m mean”), the t-test shows that the differences are not significant. Differences in degrees of freedom (DF) are caused by zero-catches of turbot and brill.

Table 3. *The effect of haul duration on total catch (kg) and catch efficiency (kg/h). For each species the average (mean) total catch, catch efficiency per haul duration (180m, 120m), the standard deviation (SD) of total catch and catch efficiency, the results of the Welchs t-test and corresponding indicator of significance (S=Significant, NS=Not significant) at the significance level of 0.05 are displayed.*

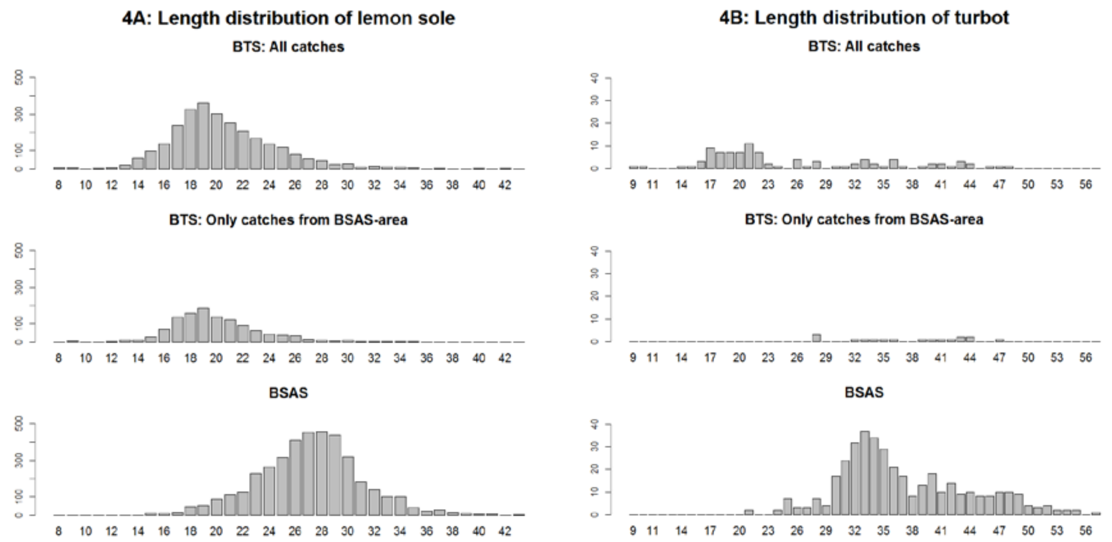
Species		**180 minutes**		**120 minutes**		**T-test results**			
		Mean	**SD**	**Mean**	**SD**	**t-value**	**DF**	**p-value**	**Significance**
Turbot	Catch (kg)	14.2	14.4	21.4	23.1	0.917	22	0.369	NS
	CpUE (kg/h)	4.7	4.8	10.7	11.5	1.656	15	0.119	NS
Brill	Catch(kg)	2.7	4.5	5.4	7.4	1.107	22	0.280	NS
	CpUE (kg/h)	0.9	1.5	2.7	3.7	1.590	15	0.133	NS
Lemon sole	Catch(kg)	49.4	47.4	26.4	27.0	-1.461	22	0.158	NS
	CpUE (kg/h)	16.5	15.8	13.2	13.5	-0.544	22	0.592	NS

3.2 Comparison with BTS

BTS data of 2014 were used for length comparisons. As age data of 2014 for turbot, brill and lemon sole was not (yet) available for 2014, the BTS 2013 data were used to compare age ranges. The data collected in this pilot survey are referred to as BSAS (Industrial Survey Associated Species) data.

3.2.1. Length distribution

For all species, the length distribution of the BSAS catches was visually compared with the length distribution of the BTS catches within the sampling area of the BSAS and with the total BTS catches (figure 4). The range of lemon sole is shifted towards larger individuals for the BSAS compared with the BTS (figure 4A). No area effects can be observed between BTS all catches and BTS only BSAS-area catches for lemon sole. Therefore, the differences between BTS and BSAS catches in the sampling area are probably due to the differences in mesh size. Turbot and brill are caught in very low numbers in the BTS (figures 4B and 4C respectively). Catches are much higher for the BSAS. Differences in length ranges between BTS areas can be observed for turbot and brill. Brill of around 12-15 cm is caught in the total BTS, but not in the BSAS-area (figure 4C). This might reflect a spatial distribution of small brill outside the BSAS sampling area. For turbot, this pattern is visible as well, but less clear than for brill (figure 4B).



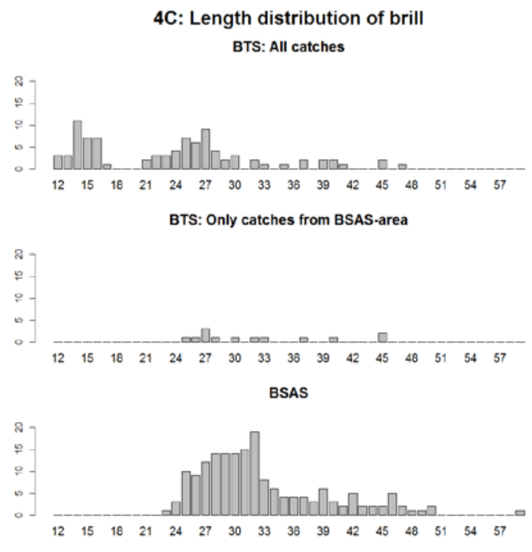
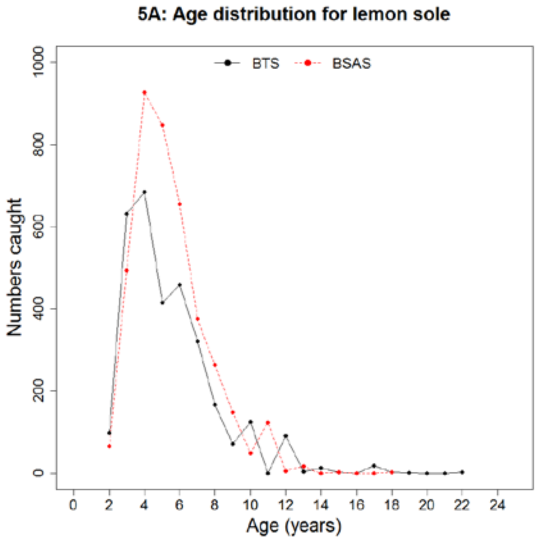
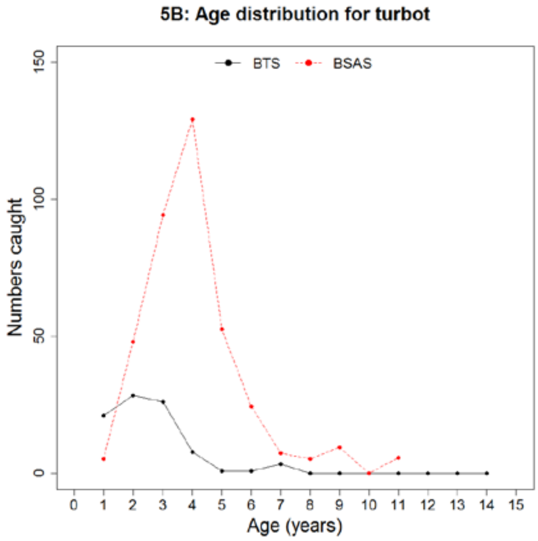


Figure 4. *Length distributions for the total catch. On the horizontal axis the observed length range for that species is displayed, while at the vertical axis the total number for each length is given. The length distribution of the catch of the BTS, the catch of the BTS within the sampling area of this industrial survey (BSAS) and the catches of the BSAS are shown for A) lemon sole, B) turbot and C) brill. Horizontal and vertical axis differ between species, but not within the three surveys for a species.*

3.2.2. Age distribution

For all species, the age distribution of the BSAS catches was visually compared with the age distribution of the BTS catches (figure 5). The age range of lemon sole in the BTS (2013 data) and the BSAS is similar, although the BTS is catching more fishes of age 2 and 3, while the BSAS is catching more fish of ages 4-6 (figure 5A). For the older fish (ages 9 and higher) the BTS and BSAS are very similar. Turbot is caught in larger numbers in the BSAS (as already seen in the length frequency, figure 4B). However, the BTS is catching relatively more younger fish (ages 1-3), while the BSAS is relatively catching more older fish (ages 4-7) (figure 5B). No remarkable differences are observed in relative contributions of ages for the BTS and the BSAS in brill (figure 5C). Although the BSAS is catching more fish, most fish are of age 1, similar to the BTS fishes. However, the BTS is not catching brills older than 4 years while the BSAS is.





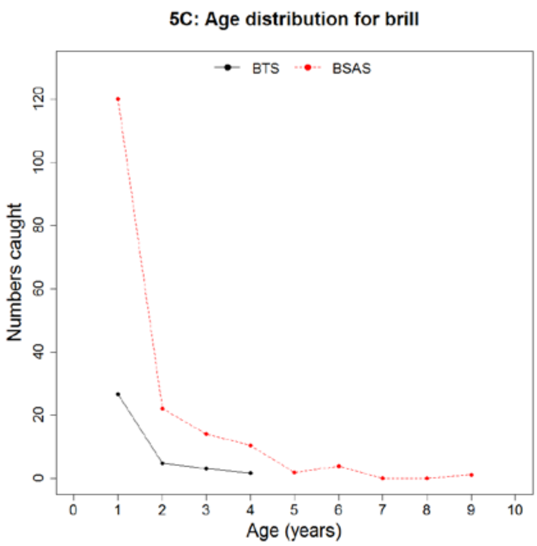
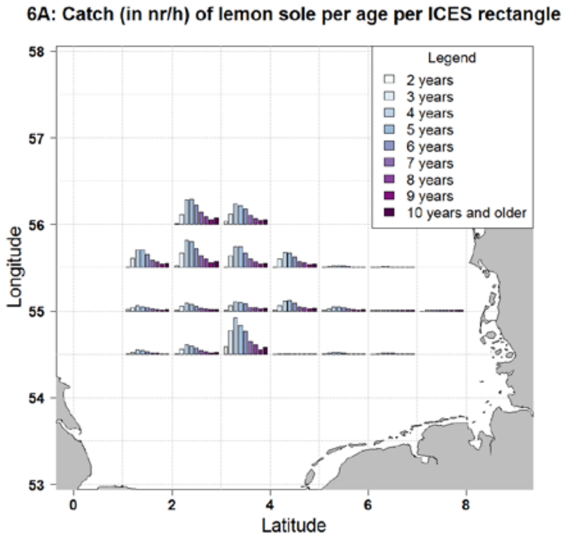
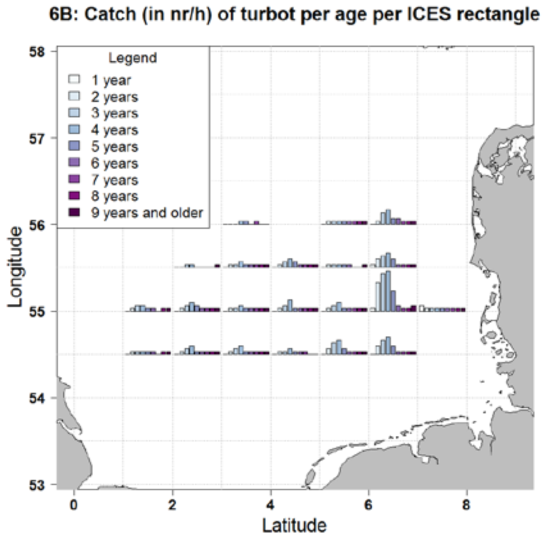


Figure 5. *Age distributions for both the BTS 2013 (black) and the BSAS (red, dotted). The number of fishes caught (vertical axis) is displayed for each age (horizontal axis) for A) lemon sole, B) turbot and C) brill. As the effort between the surveys differs, no direct comparisons should be made in absolute numbers caught within the surveys.*

3.3 Spatial age distribution

Important for a survey is that the sampled population is representative for the total population. Therefore, the spatial composition of the ages was determined (figure 6). For lemon sole hardly any spatial effects can be seen in the age distribution (figure 6A). Only in the four southwest rectangles (latitude 1-3, longitude 54.5-55.5), the population in general seems older, as the peak of ages 4-5 is no longer present. This might indicate that juveniles are located more in the northern parts. Turbot and brill mostly have younger fishes closer to shore, with peaks in lower ages in the south-eastern parts (figures 6B and 6C).





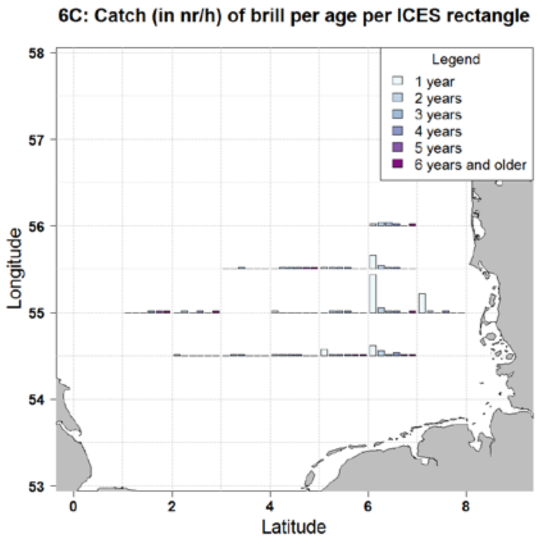


Figure 6. *Spatial age distribution in numbers per hour (nr/h) for A) lemon sole, B) turbot and C) brill. Within each ICES rectangle, a set of ages is represented by bars. The ages of the fish are color-coded, the amount of fish is represented by the height of the bar.*

4. Discussion

In 2014, Ekofish, NSF and IMARES performed a pilot-survey to 1) explore the practical feasibility and knowledge gain of an industrial survey aimed for turbot, brill and lemon sole and 2) to test several aspects of the survey design. Although surveys on fish stocks can only be used for stock assessments when a time series of multiple years exists, the pilot-survey this year can be used as an indicator for the practical feasibility and knowledge gain of such a survey. One should take into account when interpreting the results and conclusions of this report that they are based on data of one year only.

4.1 Lemon sole

Lemon sole is caught in similar numbers in the BTS as in this pilot-survey (figure 4). However, the BSAS is more effective in catching larger lemon sole, while the BTS is having higher catch rates for smaller lemon soles (figure 4). Because there is no difference in average length between the BTS in the BSAS sampling area and in the total BTS, the difference between length ranges in the BSAS and the BTS can probably be explained by the differences in mesh size used in the two surveys. The BTS is fishing with a beam trawl net equipped with meshes of 40mm, while in the BSAS the minimum mesh size used was 100mm. The oblong shape of a lemon sole is probably responsible for the low catch rates of small lemon sole with larger mesh sizes, as they can easily go through the meshes of the net. Interestingly, the observed age ranges in lemon sole in the BSAS are not substantially different from the BTS (figure 5). This could be caused by the slow growth curve after the first year of a lemon sole (Mahé et al. 2010).

Stock assessments use survey data to fine-tune their catch data. Absolute numbers are not powerful, but the relative changes in numbers are. Therefore, it is important for a survey to catch a wide range of ages, so that a year-class can be studied between years. For lemon sole, the observed trends in the BTS and in the BSAS are similar, as a wide range of ages is caught. Although the BTS and BSAS numbers presented in figure 5 should not be compared (as fishing effort is not equal between these surveys), one can already “follow” a year class. As the BTS age data are collected in 2013, the BSAS are representing fishes that have survived one extra year. The small peak in the BTS at age 11 is continued in the BSAS as a small peak in age 12 (figure 5A).

This report demonstrates that for lemon sole, the BTS data should be sufficient to conduct population trends, which may be used in stock assessments. An extra industrial survey aiming for lemon sole would therefore not be necessary.

4.2 Turbot and brill

In this survey, turbot and brill are caught in much larger numbers than in the BTS (figure 4). Several aspects may cause this difference. First, the BTS is using a beam trawl with a beam length of 8m. It is argued that a large turbot/brill individual is able to escape the BTS gear by moving outside the reach of the beam (to the side). In the BSAS the nets combined have an opening of around 200m wide, making this escape route relatively less important. Furthermore, the (large) fishes are expected to outswim the net, as BTS is fishing at a lower speed than the commercial fisheries are. Especially as the BTS is only performing hauls of 30mins, while in the BSAS hauls have a duration of 2 or 3 hours. Combining the shorter duration and smaller net opening, the BTS has a much smaller effective swept area than the BSAS. Therefore, the chance to encounter the fishing net is much larger in the BSAS.

Either way, the BSAS is catching much more turbot and brill than the BTS is. This affects the length and age ranges in a positive way. Trends are hard to spot when catches are low within years. Therefore, accurate estimations about the population cannot be made based on the catches in the BTS. An industrial survey, like the BSAS, could improve the accuracy of population trends, which could be used in future stock assessments.

As can be observed in the spatial distribution of the catches (figure 3B and 3C), turbot and brill have the highest concentrations in the south-eastern part of the sampling area. For turbot and brill, it may therefore be recommended to move the sampling area more towards the southeast.

4.3 Survey design

Depending on the choice for species aimed for, the survey can be re-designed towards a survey completely aimed for a specific species. For both parameters tested in this pilot-year (haul duration and mesh size), results can be used to fine-tune the survey design. If this survey is to be continued, choices about haul duration, mesh size and sampling area should be made. Where mesh sizes are expected to decrease the minimum length of the fish caught (and therewith maybe increase total catches), haul duration could affect the catch in two ways. First, one would expect higher catches in the longer duration-hauls, as more fish are encountered. Secondly, with a longer duration, the fish have a higher chance of getting exhausted and therefore end up in the net. Whereas the first effect will alter the total kilo of fish caught in a haul, the second effect will alter the catch per hour.

The results of this pilot-study showed that only lemon sole numbers were positively affected by a decrease in mesh size. Turbot and brill catches were not affected. Haul duration did not affect any species significantly. However, with hauls of only two hours the catches were still fairly good, indicating that in a sequel survey hauls of two hours are probably sufficient.

The effects of sampling area were not tested this year, but spatial distributions of catches can be used as indicators for the “completeness” of the sampling area. As observed in figures 3 and 6, lemon sole has a different distribution area than turbot and brill, with the juveniles even further apart (outside the sampling area). The most appropriate sampling area can therefore only be determined when the species of interest are stated.

5. Conclusions and recommendations

5.1 Conclusions

This report presents the data collected in the pilot-survey of Ekofish, NSF and IMARES. Based on the results, the following conclusions can be drawn:

- **Lemon sole** is caught in large numbers, both in the BSAS as in the BTS.
- **Lemon sole** individuals caught in the BSAS are on average of larger lengths than in the BTS.
- The age ranges of **lemon sole** in the BTS and in the BSAS are similar, with for BSAS most fishes between 4-7 years and in the BTS the peak between 3-6 years.
- The BTS has good **lemon sole** catches, in a wide range of lengths and ages. The BTS data can therefore be used for accurate population trends, and potentially in stock assessments.
- **Turbot** is infrequently caught in the BTS, but frequently in the BSAS.
- A more representative length-distribution is available for **turbot** due to BSAS catches.
- **Turbot** age distributions are more accurate, as total numbers per age have increased with respect to BTS age data.
- **Brill** is infrequently caught in the BTS, but frequently in the BSAS.
- **Brill** age distributions are more accurate, as total numbers per age have increased with respect to BTS age data.
- Age distributions for **brill** have a larger range, ranging from 1-9 years instead of 1-4 years with the BTS age data.
- The BTS is sampling in locations where smaller **brill** and **turbot** are present with respect to the BSAS-sampling area.

5.2 Recommendations

Based on the results, discussion and conclusions of this report, we make the following recommendations:

- Continuation of this industrial survey for lemon sole would probably not be useful, as the BTS is already resulting in accurate data of the lemon sole population.
- A data-exploration on (international) lemon sole data might stimulate discussion on an analytic stock assessment for lemon sole.
- Continuation of this industrial survey for turbot and brill would be useful, as the BTS is not catching turbot and brill frequently. The knowledge gained by this industrial survey for population trends could be substantial. However, a time series of multiple years should be established before the collected data can be used in for instance stock assessments.
- If this survey is continued as a survey aimed for turbot and brill:
    - A southeast oriented shift in sampling area would probably result in a closer match with the natural spatial distribution of turbot and brill.
    - Haul duration should be standardised. As turbot and brill catches were not significantly affected by haul duration, it would be advisable to set haul duration to two hours.
    - Mesh size should be standardised. As turbot and brill catches were not significantly affected by mesh size, the used mesh size should be determined based on possible other target species.
    - It would be wise to check spatial distributions for other species measured in this survey, and include species with similar spatial distributions.

Quality Assurance

IMARES utilises an ISO 9001:2008 certified quality management system (certificate number: 124296-2012-AQ-NLD-RvA). This certificate is valid until 15 December 2015. The organisation has been certified since 27 February 2001. The certification was issued by DNV Certification B.V. Furthermore, the chemical laboratory of the Fish Division has NEN-EN-ISO/IEC 17025:2005 accreditation for test laboratories with number L097. This accreditation is valid until 1th of April 2017 and was first issued on 27 March 1997. Accreditation was granted by the Council for Accreditation.

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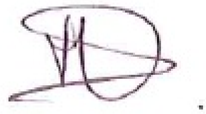
Justification

Rapport: C036/15
Project Number: 4301502601

The scientific quality of this report has been peer reviewed by the a colleague scientist and the head of the department of IMARES.

Approved: Harriet van Overzee
Fisheries researcher

Signature:



Date: February 20, 2015

Approved: Nathalie Steins
Head of fisheries department

Signature:

Date: February 20, 2015