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Report of the Benchmark Workshop on Norway Pout (*Trisopterus esmarkii*) in Subarea 4 and Division 3a (North Sea, Skagerrak, and Kattegat)

23–25 August 2016

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Executive summary

The Benchmark Workshop on Norway Pout (WKPout), chaired by External Chair Jerry Ault, USA, and ICES Chair José De Oliveira, UK, met at ICES HQ, Copenhagen on 23–25 August 2016. There were 13 participants, including three external reviewers (two from USA, one from France), Danish, Norwegian and UK scientists, and Danish Industry representatives. The benchmark followed a data evaluation workshop in May 2016 during which input data for the assessment were agreed. The main focus of the benchmark was to agree a new assessment methodology, seasonal SAM (SESAM), for Norway Pout. In addition, reference points and forecasting methodology were discussed. A number of variants of the SESAM model were investigated and compared to the previous assessment model, SXSA. These variants included the use (or not) of commercial cpue data, omission of the earliest years of data from the assessment, alternative settings for the detection threshold used to handle zero-valued data, and omitting the years of fishery closure when estimating the random walk variance on fishing mortality. The final SESAM model excludes commercial cpue data, omits 1983 data from the assessment and omits the years of fishery closure from the random walk variance calculation. B_{lim} is set equal to B_{loss} based on quarter 4 SSB values to align with the new fishing season (1st November to 31st October). The short-term forecast is stochastic, which allows the probability of SSB being below B_{lim} to be evaluated immediately following the fishing season.

1 Introduction

1.1 Terms of Reference

2015/2/ACOM36 A **Benchmark Workshop on Norway Pout** (WKPout), chaired by External Chair Jerry Ault, USA, and ICES Chair José De Oliveira, UK, and attended by three invited external experts Jerry Ault, USA, Verena Trenkel, France and Daniel Hennen, USA will be established 18–19 May 2016 for a data evaluation meeting at ICES Headquarters and at ICES in Copenhagen, Denmark, 23–25 August 2016 for a Benchmark meeting, to:

a) Evaluate the appropriateness of data and methods to determine stock status and investigate methods for short-term outlook taking agreed or proposed management plans into account for the stocks listed in the text table below. The evaluation shall include consideration of:

i) Stock identity and migration issues;

ii) Life-history data;

iii) Fishery-dependent and fishery-independent data;

iv) Further inclusion of environmental drivers, multispecies information, and ecosystem impacts for stock dynamics in the assessments and outlook.

b) Agree and document the preferred method for evaluating stock status and (where applicable) short-term forecast and update the stock annex as appropriate. Knowledge of environmental drivers, including multispecies interactions, and ecosystem impacts should be integrated in the methodology.

If no analytical assessment method can be agreed, then an alternative method (the former method, or following the ICES approach for stocks without analytical assessments) should be put forward;

c) Re-examine and update, if necessary, MSY and PA reference points according to ICES guidelines (see reports of WKMSYREF 2–4 and the Technical document on reference points);

d) Bearing in mind that the catch advice for Norway pout is for the period November 1 of the assessment year to October 31 of the following year, evaluate the settings of the escapement strategy used in the ICES MSY approach and the value of $F_{cap.}$

e) Develop recommendations for future improving of the assessment methodology and data collection;

f) As part of the evaluation:

i) Conduct a three day data evaluation workshop. Stakeholders are invited to contribute data (including data from non-traditional sources) and to contribute to data preparation and evaluation of data quality. As part of the data evaluation workshop consider the quality of data including discard and estimates of misreporting of landings;

ii) Following the data evaluation correspondence work, produce working documents to be reviewed during the Benchmark meeting; these documents should be available at least seven days prior to the meeting.

STOCKS	STOCK LEADER
Nop-34	J. Rasmus Nielsen

The Benchmark Workshop will report by 15 September 2016 for the attention of ACOM.

1.2 Conduct of meeting

The meeting was held over three days at ICES HQ, Copenhagen. Participants are listed in Annex 1 and the Agenda shown in Annex 2. The working documents presented are given in their entirety in Annex 3; portions of WD6 (SESAM assessment) have been integrated into Sections 3.6.5, 3.7 and 3.8. Annex 4 provides the brief report (and associated appendices) from the DEWKPOUT (the data evaluation workshop held in May 2016), while Annex 5 provides the link to the updated Stock Annex.

2 Description of Benchmark Process

The benchmark process commenced with the data evaluation workshop held over 18–19 May 2016. The short report from this meeting is shown in Annex 4. Subsequent to this workshop, a planning meeting (by correspondence) was held to discuss work plans and the working documents to be expected (6 July 2016; did not include the reviewers), followed by another meeting (also by correspondence; 9 August 2016) to introduce the reviewers into the process and discuss progress. During the benchmark itself, six working documents (WDs) were presented, covering all aspects of the ToRs. These WDs are given in Annex 3. The ToRs were also addressed by drawing on work carried during previous benchmarks and the 2012 inter-benchmark meeting, and by drawing on analyses and information already reported in the stock annex.

The main focus of this meeting was to upgrade the assessment model for Norway Pout from seasonal XSA (SXSA) to a seasonal SAM model (SESAM), run with a quarterly time-step. The advantages of moving to SESAM are covered in Section 3.9 (External Reviewers' comments), as discussed during the benchmark; these include its ability to incorporate process and observation error and estimate uncertainties in all quantities, including the forecast. For the purposes of developing the SESAM model and to allow comparisons with SXSA, data from the May 2014 assessment was used.

The benchmark considered a number of variations of the SESAM model (nine in total), covering use or not of the commercial cpue, sensitivity to the use of a detection limit used to handle zero-value data points, the exclusion of the earliest years of data due to concerns about how mean weights-at-age in the catch were derived, and the exclusion of the years of fishery closure when estimating the random walk variance. These nine variations are reported in detail in WD6 (Annex 3). The final assessment is reported in Section 3.6.5, and an example forecast (for a May assessment) and associated B_{lim} calculation are covered in Sections 3.7 and 3.8 respectively.

3 Norway pout (*Trisopterus esmarkii*) in Subarea 4 and Division 3.a (North Sea, Skagerrak, and Kattegat)

Norway pout last underwent an inter-benchmark in March–April 2012, which evaluated alternative biological inputs in the stock assessment for natural mortality, sexual maturity and growth (mean weight-at-age in the stock).

3.1 Stock ID and substock structure

Norway pout is a small, short-lived gadoid species, which rarely grows older than five years (Nielsen *et al.*, 2012, Lambert *et al.*, 2009). It is distributed from the west of Ireland to Kattegat, at the Faroe Islands, and from the North Sea to the Barents Sea. The distribution for this stock is in the northern North Sea (>57°N) and in Skagerrak at depths between 50 and 250 m (Raitt, 1968; Sparholt *et al.*, 2002b). The stock distribution and density patterns as well as maturity, spawning, spawning distribution and migration relevant to the stock distribution and delineation are described in detail in Nielsen (2016; WD1, Annex 3). In general, highest densities of Norway pout of all age groups are found in the northern North Sea. Densities by year vary according to strong cohorts in the stock. The strong cohorts observed in the period are the 1986, 1989, 1991, 1994, 1996, 1999, 2008, 2009, 2012, and 2014 year classes. There seems to be a tendency towards the young fish density having decreased in the later period compared to the previous period before and after year 2000 (see Section 1, Figures 1 and 2 of WD1, Annex 3).

At present, there is no evidence for separating the North Sea component into smaller stock units (Lambert *et al.*, 2009; Nash *et al.*, 2012). ICES Advisory Committee for Fisheries Management (ACFM) asked in October 2001 the ICES Working Group on the Assessment of Demersal Stocks in the North Sea and Skagerrak (ICES, WGNSSK) to verify the justification of treating ICES Division 5.a as a management area for Norway pout (and sandeel) separately from ICES areas 4 and 3.a. Preliminary results from an analysis of regionalized survey data on Norway pout maturity, presented in a Working Document to the 2000 meeting of the ICES WGNSSK Working Group (Larsen *et al.*, 2001 in ICES C.M.2001/ACFM:07), gave no evidence of a stock separation in the whole northern area. This conclusion is supported by the results from the maturity and spawning analyses presented in Lambert *et al.* (2009) and Nash *et al.* (2012) as well as Huse *et al.* (2008). Here it was found that spawning in the North Sea takes place mainly in the northern part in the area between Shetland and Norway in coastal waters along the 120 m isocline (Lambert *et al.*, 2009). The results from Nash *et al.* (2012) also suggest one main spawning area and accordingly only occurrence of one stock component in the whole northern area on the shelf area.

Norway pout in the eastern Skagerrak is only to a very small degree a self-contained stock and adults migrate out of the Skagerrak and the Kattegat to spawn, because there is no evidence of spawning there (Poulsen, 1968). The main bulk drifts as larvae southeastwards from more western areas to which they return mainly during the latter part of their second year of life before becoming mature (Poulsen, 1968; Lambert *et al.*, 2009; Nash *et al.*, 2012).

Also, the conclusion on one stock component is supported by the depth distribution limits of the species (Poulsen, 1968; Albert, 1994; Sparholt *et al.*, 2002b; Lambert *et al.*, 2009; Nielsen *et al.*, 2012), i.e. there is no indication that the species migrate outside the shelf areas into deeper waters than 200 m depth. For the Norwegian Trench Albert

(1994) found Norway pout deeper than 200 m, but very few deeper than 300 m. However, very few Norway pout are caught at depths greater than 200 m in the North Sea and Skagerrak on shrimp trawl survey (Sparholt *et al.*, 2002b; Johnsen and Søvik, 2016, WD5).

Details on stock delineation according to stock distribution and density patterns as well as maturity, spawning, spawning distribution and migration can be found in Nielsen (2016; Sections 2–4 in WD1, Annex 3).

3.2 Issue list

Data needed

Research survey data with cpue and stock indices by age from 1983 (where available) and onwards for all age groups: IBTS Q1, IBTS Q3, EGFS Q3, SGFS Q3.

Danish and Norwegian catch (catch-at-age) and effort (fishing days) and vessel size (horse power) data by quarter by métier (and also sorted according to selective devices mounted on the trawls, e.g. sorting grids/panels) from 1983 onwards. The horse power categories are in 100 hp classes. (0–100, 100–200, 200–300, etc.).

Data need to be uploaded to InterCatch for Norway as well. To ensure anonymity of the Norwegian vessels, the horse power interval categories has to been wider (e.g. 0–500, 500–1000, etc.) as there are very few Norwegian vessels fishing Norway pout. This is reported to InterCatch.

Test age-reading data: Age-reading tests and check between DK and Norway; ongoing.

Additional relevant information: There are no major data deficiencies identified for this stock, whose assessment is usually of high quality. However, some detailed information on distribution of different life stages will be very welcome. For example precise indications on spawning sites and spawning periods (i.e. observations of fish with running roe or just post-spawned fish); information/data on detailed distribution changes of different size groups e.g. on the Fladen Ground (outer bank, inner bank according to age; schools of size groups or mixing; vertical distribution patterns) over the fishing seasons and changes herein will be welcome (especially 1st, 3rd and 4th quarter). Potential distribution patterns regarding when and where it is possible to obtain the cleanest Norway pout fishery, i.e. with minimum bycatch would be important, as well as information on potential diurnal changes in distribution, density, and availability. Potential changes in the southern borders of its distribution range in the North Sea would also be relevant to obtain according to a potential temperature effect of climate driven sea warming. Detailed sampling of Norway pout individuals from the commercial fishery in quarter 1 and quarter 4 will be welcome in order to establish more precisely the exact spawning sites (areas) and precise spawning time based on biological examination of maturity stages of these sampled individuals. The above information will demand self-sampling by the fishermen in their quarter 1, 2 and quarter 4 fishery covering all fishing areas and the whole season. In general fishing effort is higher in second half year compared to 1st half year.

Current assessment issues

1) Future benchmark should promote that a quarterly based stochastic assessment model is developed which can be applied for the stock assessment, e.g. a quarterly based SAM model.

Future benchmark should promote that a quarterly based stochastic assessment model is developed which can be applied for the stock assessment, e.g. a quarterly based SAM model. Recent developments in relation to implementation of seasonal stochastic assessment models not dependent on constant exploitation patterns (F-patterns between years and ages) should be considered for the assessment of the stock. Future benchmark should promote that a quarterly based model (e.g. the SAM assessment model) is developed which can be applied for the stock assessment. Another possibility is to evaluate survey based assessment and/or more simple assessment methods, i.e. assessment of stock status based exclusively on survey indices can also be considered. In such an approach the robustness of and consistency in survey indices should be further evaluated.

2) Review specific biomass reference points considering:

- Changed assessment year;
- Forage fish species with variable natural mortality;
- Discuss and test new SMS 2015 key run data with respect to M2 values compared to the ones found in recent primary literature;
    - Area differences in M2 values?
    - Time and area variances according to predation and availability of forage fish for predators (is Norway pout a food limiting factor for predators)?

An inter-benchmark was carried out in spring 2012 (IBPNorwayPout, ICES, 2012c) evaluating revised estimates of natural mortality, maturity-at-age and mean weight-at-age in the assessment. This has led to a revised assessment, and a summary of the results is given in the present report as well as in the **Stock Annex**, and the details of the inter-benchmarking are given in the IBPNorwayPout Report (ICES, 2012c). The benchmark group did not recommend revised reference points for the stock at this stage, but concluded that higher escapement targets could be considered in future based on the importance of Norway pout as a forage species in the ecosystem. The consumption amount of Norway pout by its main predators should be evaluated in relation to production amount in the Norway pout stock under consideration of consumption and production of other prey species for those predators in the ecosystem. The consumption amount of Norway pout by its main predators should be evaluated in relation to production amount in the Norway pout stock under consideration of consumption and production of other prey species for those predators in the ecosystem over time and in different areas. This also implies need for information on prey switching dynamics of North Sea fish predators which also are foraging on Norway pout. Can standard single species assessment models cope with this situation and describe the dynamics adequately?

3) Future benchmark should evaluate usefulness of including recent commercial fishery tuning time-series in the assessment from Danish and Norwegian commercial fishery. This should take into consideration influence on cpue and targeting in the Norway pout fishery based on the several fishing closures (several real-time management closures) in recent years, introduction of selective devices in recent years being different for Norwegian and Danish fishery, different targeting in Danish and Norwegian Norway pout fisheries (Norway pout, blue whiting), different area specific effort allocation of Danish and Norwegian fisheries, as well as yearly changes in fleet specific efficiency given changes in vessel sizes targeting Norway pout over time. Fleet specific catch-effort data time-series according to fleet categories

(vessel sizes) as well as in relation to use of selective devices and including data on spatio-temporal effort allocation for both Danish and Norwegian fisheries (fleets) will be needed to make the necessary fishing power analyses in order to standardize effort and cpue indices between fisheries and fleets.

4) Previously, there have been no reports of age-reading problems of Norway pout otoliths, and no indications of low quality of the age–length keys used. However, a preliminary analysis presented in WD4 (Annex 3) indicates problems and discrepancies in age readings between Denmark and Norway. To meet this, a full exchange program has already been launched as described in WD4 (Annex 3), to be conducted 2016–2017.

5) New research findings on developments in bycatch reducing gear devices should be further evaluated under ecosystem aspects and fisheries aspects in relation to future benchmark assessment.

Proposed working papers/analyses

1) Seasonal SAM assessment development, including 3–5-year back comparison with SXSA, and sensitivity analysis [led by Rasmus Nielsen]

2) Forecast methodology, and MSY and PA reference points, including implications of sensitivity analysis and ecosystem considerations [led by Rasmus Nielsen]

3) Norwegian fishery description and cpue analysis [led by Espen Johnsen]

4) Danish fishery description and cpue analysis [led by Rasmus Nielsen]

5) Existing supporting documents on historic catches (Industrial fisheries Expert Group, EU-Norway negotiations) [coordinated by Rasmus Nielsen]

6) Age-reading data comparisons [coordinated by Rasmus Nielsen]

7) Norwegian Shrimp survey estimates east of Norwegian trench (comparing perceptions with IBTS surveys), as supplementary information only (not as a tuning series) [led by Espen Johnsen]

Workplan (recommendations from DEWKPOUT)

- Keep current datasets (current catch, current historic cpue and current IBTS Q1, Q3 and UK-Q3-EGFS and UK-Q3-SGFS) and develop SAM assessment
    - Check whether discards can be included or not (include if yes)
    - Keep SXSA assessment as an alternative assessment for comparison at the benchmark
- Develop forecast methodology
- Develop MSY and PA reference points (including ecosystem considerations)
- Conduct sensitivity analyses:
    - Remove historic commercial cpue from the assessment
- Compile time-series of effort and compare to changes in F
    - Norwegian and Danish data available

3.3 Scorecard on data quality

A scorecard was not provided for this benchmark.

3.4 Multispecies and mixed fishery issues

Details on intraspecific and interspecific (multispecies) dynamics in relation to Norway pout in the North Sea are presented and evaluated in Nielsen (2016; Section 6 in WD1, Annex 3).

3.4.1 Multispecies information and considerations in relation to the species ecological role

Norway pout natural mortality is likely influenced by spawning and maturity having implications for its age-specific availability to predators in the ecosystem and to the fishery (Nielsen *et al*., 2012).

In previous ICES stock assessments it has under ecosystem consideration been noted that there is a need to ensure that the Norway pout stock remains high enough to provide food for a variety of predator species (e.g. ICES, WGNSSK 2011a). This stock is among other important as food source for the species saithe, haddock, cod, whiting, and western mackerel and predation mortality is significant (ICES, WGSAM 2014 with most recent 2013 SMS Key Run; ICES-WGSAM 2011; ICES-SGMSNS 2006). Especially the more recent high abundance of saithe predators and the more constant high stock level of western mackerel as likely predators on smaller Norway pout in the North Sea are likely to significantly affect the Norway pout population dynamics.

The ICES inter-benchmark assessment in spring 2012 (IBPNorwayPout, ICES 2012c) evaluated multispecies considerations in relation to the natural mortality population dynamics parameters in the benchmarking for Norway pout stock in the North Sea and Skagerrak including predation mortality. In the 2012 inter-benchmark a series of assessment scenarios were run with different parameter settings of natural mortality. Natural mortality has been derived from analysis of total mortality rates estimated from IBTS survey catch rates (cpue from IBTS Q1 and Q3) using the approach described in Nielsen *et al*. (2012); Lambert *et al*. (2009) and Sparholt *et al*. (2002a,b). Furthermore, natural mortalities derived from the multispecies SMS model from the 2011 SMS key run were used in one of the exploratory scenarios (Scenario 4) in the benchmarking. This is described under natural mortality in Section 3.6.4 of the IBPNorwayPout report (ICES, 2012c).

The 2012 inter-benchmark introduce revised estimates of maturity and natural mortality and maturity-at-age used in the Norway pout stock assessment. The background and rationale behind the revision of the natural mortality and maturity parameters is described in the IBPNorwayPout report (ICES, 2012c) and primary literature (e.g. Nielsen *et al*., 2012; Lambert *et al*., 2009; ICES, WGSAM 2011)). A follow up on this analysis is presented in Nielsen (2016; Section 3 in WD1, Annex 3) with the same conclusions.

The inter-benchmark (IBPNorwayPout, ICES 2012c) group did not recommend revised reference points for the stock at this stage, but concluded that higher escapement targets could be considered in future based on the importance of Norway pout as a forage species in the ecosystem. The consumption amount of Norway pout by its main predators should be evaluated in relation to production amount in the Norway pout stock under consideration of consumption and production of other prey species for those predators in the North Sea ecosystem. There most likely is difference in preference and switching between prey species and size groups by different predator species, and in different areas and seasons having different communities and foodwebs. Those factors and their variability needs to be taken into account when trying to establish target reference levels for Norway pout based on estimating necessary Norway pout biomass to be available for predators in the North Sea and Skagerrak. This should be considered for all prey species together for those predators and not only for Norway pout isolated.

The WGNSSK Assessment Review Group (WGNSSK 2007) asked the WG to provide guidance on how to deal with the objective of keeping a certain amount of biomass for predators. Here it was noted that if a minimum biomass is found to be required, then natural mortality could not be kept constant in the prediction (as it does during the assessment period).

It should be noted that natural mortality levels by age and season used in the stock assessment reflect the predation mortality levels estimated for this stock in the most recent multispecies stock assessment performed by ICES. Natural mortality levels by age and season used in the stock assessment do include the predation mortality levels estimated for this stock (ICES-WGSAM 2014 ICES-WGSAM 2011; ICES-SGMSNS 2006), and in the 2012 Inter-benchmark assessment revised values for natural mortality have been used which also include the estimated levels of predation mortality in the 2011 and 2013 SMS key/baseline run multispecies assessments (ICES-WGSAM 2011; 2014).

Intraspecific dynamics

Interspecific and intraspecific density patterns in Norway pout mortality has been documented (e.g. Nielsen *et al*., 2012; Nash *et al*., 2012; Lambert *et al*., 2009; Kempf *et al*., 2009; Cormon *et al*., 2016).

Concerning intraspecific interactions and potential density-dependence then the juvenile growth rate is higher when the stock density is low and results in a reduced age-at-50%-maturity (Lambert *et al*., 2009). The study by Lambert *et al*. (2009) showed only weak intraspecific density-dependence in growth and maturity, as well as in age and length-at-maturity, but the general trend found was that both these parameters decreased with the number of fish in a cohort. Although these correlations could highlight a phenomenon of density-dependence linked to local aggregation (as for herring; Engelhard and Heino, 2004) or food availability, perhaps the reductions can be explained by density- and size-dependent juvenile mortality (Lambert *et al*., 2009).

Nielsen *et al*. (2012) found that natural mortality (M) is significantly correlated with sexual maturity, sex, growth, and intraspecific stock density. According to Nielsen *et al*. (2012) the density-dependence, either intra- or interspecific, of NP mortality showed a distinct pattern. They found that mortality was significantly positively correlated with intraspecific population density. The NP population dynamics seemed, therefore, to be influenced by density-dependence, which resulted in a lower growth rate and maturation when the stock was at a relatively high level. Thus, bringing together the varied information pertaining to NP mortality, it is likely that lower stock densities contribute to higher growth rates and higher maturity ratios and, consequently, greater mortality rates, which are most likely caused by spawning. Kempf *et al*. (2009) found no intraspecific relationship between NP SSB in the year of birth and the IBTS age 1 recruitment index of the following year, whereas the interannual variability of age 1 recruitment was found to be correlated with the Q2 sea surface temperature (SST) when taking predation impact into consideration. However, this was not highly significant and included the removal of years characterized as outliers. Although the analyses of Nielsen *et al*. (2012) indicated density-dependent mortality which could be associated with spawning and that available documentation on predation could not explain the observed increase in Z at-age, it was difficult to disentangle density-dependent mortality and size-selective mortality (Nielsen *et al*., 2012). Size-selective mortality will usually result in greater mortality of the smallest (youngest) fish, but for Norway pout, greater mortality rates for the largest (oldest) fish were observed, and that spawning was not only associated with age, but also with size. Nielsen *et al*. (2012) found evidence of spawning mortality where the fastest growing individuals mature faster and therefore spawn and die faster, but also found that there may be other reasons for such reversal size-selective mortality, e.g. density-dependence. They argued that density-dependence probably did not influence mortality directly, but rather indirectly as explained above, and can also be influenced by size-selective mortality other than spawning mortality, so no rigorous conclusions can be made on this.

Interspecific dynamics

Besides intraspecific patterns, the growth rates show interspecific links to stock sizes of the important predators: cod, haddock, and whiting (Lambert *et al*., 2009). Especially interspecific density-dependent patterns in Norway pout growth and maturity were found in relation to North Sea cod and whiting stock abundance (Lambert *et al*., 2009). The interspecific density-dependence in growth of Norway pout found by Lambert *et al*. (2009) revealed a positive correlation between whiting SSB and growth, and a negative one with cod and haddock SSB. Cod and haddock being larger species probably target larger prey, whereas whiting likely target smaller Norway pout. However, other factors could influence these observations. Raitt and Adams (1965) compared the feeding habits of Norway pout and whiting and showed an extensive overlap between what 0-group whiting and adult Norway pout were eating. Therefore, even if adult whiting are important predators on small Norway pout (Jones *et al*., 1954; Daan and Welleman, 1998), the positive correlation between both could be due to simple food availability and the effects of competition for food lowering the MWA for Norway pout and whiting recruits. Depending on the strength of the stock–recruitment relationship for whiting, this could affect the relationship between Norway pout growth and whiting SSB (Lambert *et al*., 2009).

Interspecific density-dependence and predation were not significant factors influencing Norway pout mortality based on the available data at the scale of the study by Nielsen *et al*. (2012), and additional studies are necessary on more disaggregated coverage and overlapping distribution and density patterns between Norway pout and its main predators by age or size group, especially during the spawning period (Nielsen *et al*., 2012). With regard to the overlap between NP and important predators in the North Sea, Rindorf *et al*. (2010) found low predated biomass and predation mortality in the main spawning areas during the spawning season. Kempf *et al*. (2009; Figure 10) found no strong correlation between the spatial overlap of NP age 1 abundance and certain NP predators (saithe, haddock, and mackerel) in the IBTS Q3 survey. However, strong predator–prey relationships do exist between some commercially important North Sea stocks and Norway pout (e.g. Cormon *et al*., 2016; Kempf *et al*., 2009; Huse *et al*., 2008). Early studies found that adult whiting is an important predator of small Norway pout (Jones, 1954; Daan and Welleman, 1998).

Based on stomach content data analyses disaggregated to ICES statistical square (area) and quarter of the year in the North Sea (1991), Rindorf *et al*. (2010) calculated biomass eaten and local predation mortality indices. They found that predated biomass (and predation mortality) of Norway pout by cod, whiting, haddock, and saithe was high in the second half of the year (Q4 and Q3) and low in the first half (Q2 and Q1). In Q1, the small Norway pout biomass eaten occurred in the most northern areas west of Orkney and south of Shetland. Based on Rindorf *et al*. (2010, Figures 2b and 5b), the areas of highest biomass predated and highest predation mortality were not in the main spawning areas during the spawning season (Q1) that were identified by Lambert *et al*. (2009, e.g. Figure 1) and Nash *et al*. (2012), i.e. the areas to be in proximity to the 120 m isobaths in ICES Roundfish Area 1 (RFA1) and RFA3 near Viking Bank along the Norwegian Trench and along the Scottish east coast (and in RFA7) in Q1. Consequently, predated biomass and predation mortality was low in the main spawning areas and during the spawning season, indicating that increased mortality cannot be explained by predation mortality.

According to Huse *et al*. (2008) several hypotheses have been advanced to explain heavy larval mortality, including predation by planktivorous fish owing to their potentially high densities and efficient foraging on fish larvae. Accordingly, a negative relationship between pelagic fish abundance and recruitment of demersal fish has been suggested for the North Sea. The recent poor recruitment to many North Sea stocks has coincided with a large herring stock, which raises the question of predatory interactions (Huse *et al*., 2008). Low recruitment of Norway pout could be due to predation by herring, because there is potential for spatial overlap between the two stocks, although there is no information available on stomach content analysis to suggest such an interaction (Huse *et al*., 2008). Herring (*Clupea harengus*) has been suggested to be a major predator on fish larvae in the North Sea, and Huse *et al*. (2008) investigated possible interactions between herring and Norway pout using a simple statistical analysis and a modified stock–recruit relationship. They found a significant negative relationship (linear regression) between total herring biomass and recruitment of Norway pout. The spawning stock of Norway pout is typically dominated by 2-year-olds, and there was a strong negative relationship (linear regression) between herring biomass and Norway pout spawning–stock biomass (SSB) two years later (Huse *et al*., 2008). A Beverton–Holt model fitted by Huse *et al*. (2008) to stock–recruit data of Norway pout produced a rather poor correlation. However, when only the Norway pout SSB not overlapping with herring was considered the fit between the model and the stock–recruit data improved. These analyses indicated a negative impact by herring on recruitment of Norway pout, the most plausible cause for this being herring predation on Norway pout larvae, but field studies are needed to verify such predation (Huse *et al*., 2008).

According to Cormon *et al*. (2016) recent assessments of the North Sea saithe *Pollachius virens*, a major top predator in the area, suggested a decrease in spawning–stock biomass along with a decline in saithe mean weight-at-ages. In this context, Cormon *et al*. (2016) investigated North Sea saithe growth characteristics at the population level: First, saithe annual weight increments and age−length relationships were studied. Then, modelling of saithe age−length relationships was carried out using (1) the traditional von Bertalanffy growth function model, (2) the Verhulst logistic model, and (3) an empirical linear model. Second, the effects of environmental factors on saithe growth were investigated. The explanatory environmental factors included in the study were food availability, represented by the total biomass of Norway pout (*Trisopterus esmarkii*); intraspecific competition, i.e. density-dependence, represented by saithe abundance; and temperature. The study of Cormon *et al*. (2016) indicated that the Verhulst logistic model was the best descriptor of saithe growth and that density-dependence and food availability had significant effects on the saithe growth coefficient, while no effect of temperature was shown. On this basis, the authors suggested that reduced food availability and increased competition may explain the recent decrease in the saithe growth coefficient. It should here be noted that the age–length keys of Norway pout survey data from the ICES IBTS surveys used in the study by Cormon *et al*. (2016) were not scrutinized and analysed on a disaggregated seasonal and area basis as the results from Lambert *et al*. (2009) revealed were necessary to obtain realistic growth data and parameters for this Norway pout stock.

The interplay between temperature-related processes and predation in determining age-1 recruitment strength between 1992 and 2006 was analysed for North Sea cod (*Gadus morhua*) and Norway pout (*Trisopterus esmarkii*) by Kempf *et al*. (2009). For this purpose, a predation impact index (PI) was calculated out of IBTS survey data. PI was assumed to depend on the abundance of the predators and on the spatial overlap between predator and prey populations. Generalized additive models (GAMs) were created with spawning–stock biomass (SSB) and sea surface temperature (SST) (SST) in the respective spawning and nursery areas and PI as explaining variables. Intraspecific SSB had no significant impact on recruitment during this time period for both species. SSTs during spring and PI explained together the interannual variability of recruitment strength to a large extent (88% of the total variance for cod and 68% for Norway pout). The SST during spring determined the overall level of recruitment. At SSTs above a certain level, however, the effect on recruitment was no longer significant. In these temperature ranges, predation was the dominant effect. On this basis, Kempf *et al.* (2009) stated that the fate of North Sea cod and Norway pout stocks under global-warming conditions will be strongly influenced by the status of the North Sea foodweb.

When scrutinizing mean predation mortality (M2) caused by predator species and age groups partly in a table with predation by predator species and age on Norway pout per age group (Table 4 in WD1, Annex 3) and a table with predation by predator species in total per Norway pout age group (Table 5 in WD1, Annex 3), as well as graphs of Norway pout relative importance (share) in diet per predator size group from the SMS 2013 baseline run then it is possible to assess the most important predators by species and age on Norway pout in the North Sea (Table 6 in WD1, Annex 3, with examples). All this information is necessary to evaluate the importance of Norway pout in the diet for the different predators and predator age groups as a high M2 can be caused by partly a large proportion of Norway pout in the diet but also by a high predator (by age) biomass / abundance. Therefore, the partial M2 is not necessarily a good measure for importance of Norway pout in the diet. Accordingly, it is also necessary to analyse graphs of Norway pout relative (share) importance in diet per predator size group.

In Nielsen (2016; Section 6 in WD1, Annex 3) the relationship between predator spawning–stock biomass and total-stock biomass for North Sea cod, haddock, saithe and whiting is shown as function of the Norway pout (prey) total-stock biomass estimated as three year running means during the period 1983–2014. The results indicate that there is a moderate positive correlation between cod spawning–stock biomass and Norway pout total-stock biomass, while there is no correlation between whiting and haddock spawning–stock biomasses and Norway pout total-stock biomass, and there is even a slight negative correlation between saithe spawning–stock biomass and Norway pout total-stock biomass. There are moderate positive correlations between North Sea cod, whiting and haddock total-stock biomasses and Norway pout total-stock biomass, while there is no (or even with negative tendency) correlation between North Sea saithe total-stock biomass and Norway pout total-stock biomass.

In Nielsen (2016; Section 6 in WD1, Annex 3) growth rates of predators vs. prey biomass are given as three years running means for different main Norway pout predators during the period 1983 to 2014. The growth rates are calculated as change in mean weight-at-age (MWA) of the predators where MWA values in the stock are obtained from the ICES WGNSSK spring 2016 assessments. The growth rates are calculated on cohort basis for the main age groups of the predators with respect to predation on Norway pout and where there are a large number of observations on MWA available. The MWA is calculated as:

$$\mathrm{MWA} = w_{a,t} - w_{a-1,t-1}$$

The results indicate that for all the predator species (cod, haddock, whiting and saithe) and their main cohorts predating on Norway pout in the North Sea there is no correlation between their growth rate in mean weight-at-age and total-stock biomass of Norway pout, except for a weak positive correlation between mean weight-at-age for 1 cohort (age 3–4) of haddock and Norway pout total-stock biomass.

3.4.2 Mixed fisheries issues

In Nielsen *et al*. (2016a; Sections A4 and A5 in WD2, Annex 3) there is given a detailed description and evaluation of bycatches in the Norway pout fishery and the gear selectivity herein as well as the discard of Norway pout in fisheries for consume purposes.

Bycatches in the Norway pout fishery and gear selectivity: fisheries impacts on the ecosystem

During the 1960s a significant small-mesh fishery developed for Norway pout and blue whiting in the northern North Sea. This fishery was characterized by relatively large bycatches, especially of haddock and whiting.

Bycatch of herring, saithe, cod, haddock, whiting, and monkfish at various levels in the small-meshed fishery in the North Sea and Skagerrak directed towards Norway pout has been documented (e.g. Degel *et al*., 2006, ICES CM 2007/ACFM:35, (WD 22 and Section 16.5.2.2)). Especially bycatch of juvenile haddock and cod as well as larger saithe has been in focus. Recent bycatch levels in the Danish and Norwegian small-meshed fisheries are given in Section A.1 of WD2 (Annex 3). Bycatches of these species have been low in the recent decade, and in general, the bycatch levels of these gadoids have decreased in the Norway pout fishery over the years to a present very low level of bycatch of other species (5–10%). WD2 (Annex 3) also presents the bycatch and relative species distribution as proportion of Norway pout, haddock and whiting in the in the Danish and Norwegian small-meshed fisheries for reduction purposes targeting Norway pout in the North Sea for the longer period 1974 to 2005 as estimated in 2007 (data from ICES 2007).

The Danish fishery has historically used two types of trawls which gives significantly different catch rates and of Norway pout and herring. Some fishermen conduct a rather clean Norway pout fishery where they use more wide trawl gears with lower gap (trawl opening height) where they catch more Norway pout and only very few herring. Other fishermen conduct a more mixed fishery targeting Norway pout and herring where they use more pelagic trawl types with larger gap and less wideness which are more efficient towards herring.

With the aim of protecting other species (cod, haddock, saithe, whiting, and herring as well as mackerel, monkfish, squids, flatfish, gurnards, *Nephrops*) a row of management measures are in force for the small-meshed fishery in the North Sea such as the area closures, bycatch regulations (bycatch quotas of herring and maximum bycatch percentages for gadoids and herring), minimum mesh size, selective grids/panels in the small-meshed gears, and minimum landing size as described under regulations in Section 3 in WD2 (Annex 3). Technical measures to protect the above mentioned bycatch species have been maintained or improved in the directed Norway pout fishery.

Gear selective devices to reduce bycatch

Review of scientific documentation show that gear selective devices can be used in the Norway pout fishery, significantly reducing bycatches of juvenile gadoids, larger gadoids, and other non-target species (Eigaard and Holst, 2004; Nielsen and Madsen, 2006, ICES CM 2007/ACFM:35, WD 23 and Section 16.5.2.2; Eigaard and Nielsen, ICES CM2009/M:22; Eigaard, Hermann and Nielsen, 2012). Sorting grids are at present used in the Norwegian and Danish fishery (partly implemented as management measures for the larger vessels), but modification of the selective devices and their implementation in management is ongoing.

From 2010 grids have been used in the Norwegian fishery. From 15th October 2012 it has been obligatory for all Danish vessels participating in the targeted Norway pout fishery in the North Sea and Skagerrak-Kattegat to use a 35 mm grid in the small-meshed trawl gears used in the fishery (typically with codend mesh sizes 16–31 mm). The introduction of the sorting grid in the Danish fishery (see below) has led to a reduction in catch rates of 5–10%. The grid reduced the bycatch of gadoids by around 50% in biomass, but it remains difficult to avoid small gadoids (Eigaard *et al.*, 2012); it also resulted in a reduction of herring bycatch. For the Norwegian fishery, area closures have had an effect on reducing bycatches in the combined Norway pout and blue whiting fishery. Introduction of selective grids in the Norwegian trawls used for this fishery has furthermore had an effect on bycatches, but some vessels do not always use this grid in the fishery (not mandatory in a part of the fishery).

Existing technical measures such as the closed Norway pout box, minimum mesh size in the fishery, and bycatch regulations to protect other species have been maintained.

Studies on selectivity in the Norway pout fishery

Early Scottish and Danish attempts to divide haddock, whiting and herring from Norway pout by using separator panels, square mesh windows, and grids were all relatively unsuccessful. More recent Faroese experiments with grid devices have been more successful. A 74% reduction of haddock was estimated (Zachariassen and Hjalti, 1997) and an 80% overall reduction of the bycatch (Anon., 1998).

Investigations of gear specific selective devices and gear modifications to reduce unwanted bycatch in the small-meshed Norway pout fishery in the North Sea and Skagerrak have been made during sea trials in year 2000 and reported through an EU Financed Project (EU, 2002), and the results from here have been followed up upon in a scientific paper from DIFRES and CONSTAT, DK (Eigaard and Holst, 2004). Previous investigations of size selective gear devices in the Norway pout trawl fishery in the North Sea was performed by IMR Norway during sea trials in 1997–1999 also published in a scientific paper (Kvalsvik *et al.*, 2006), as well as in a number of other earlier studies on the issue. Main results of previous investigations have been reviewed and summarized in Working Document No. 23 to the WGNSSK (2006) by Nielsen and Madsen (2006).

Danish-Norwegian fishing trials and pilot investigations were performed in autumn 2005 in order to explore bycatch levels in the small-meshed industrial trawl fishery in the North Sea targeting Norway pout. The results are given in Working Document No. 22 to the WGNSSK (2006) by Degel, Nedreaas and Nielsen (2006). The results were noisy and showed variable bycatch levels for different species. The investigations indicated spatio-temporal differences in catch levels by species in the commercial small-meshed fishery for Norway pout as well as an effect of targeting and use of fishing method on the bycatches. However, these patterns are only based on results from pilot investigations. Existing logbook data and knowledge of spatio-temporal patterns in catch rates of target species and bycatch species in the fishery are at present not adequate and with high enough spatial and temporal resolution to implement management measures with respect to regulations on spatio-temporal allocation of fishing effort to reduce bycatches. With regard to diurnal differences in the catch rates of Norway pout and bycatches of other species, the few pilot investigation results indicated significant lower bycatch of blue whiting during night hauls.

Eigaard and Holst (2004) and EU (2002) found that when testing trawl gears with a sorting grid with a 24 mm bar distance in combination with a 108 mm (nominal) square mesh window through experimental, commercial fishery the results showed improved selectivity of the commercial trawl with catch weight reductions of haddock and whiting of 37 and 57%, but also a 7% loss of Norway pout. The study showed that application of these reduction percentages to the historical level of industrial bycatch in the North Sea lowered on average the yearly haddock bycatch from 4.3 to 2.7% of the equivalent spawning–stock biomass. For whiting the theoretical reduction was from 4.8 to 2.1%. The purpose of the sorting grid was to remedy the bycatch of juvenile gadoids in the industrial fishery for Norway pout, while the purpose of square mesh window was to retain larger marketable consume fish species otherwise sorted out by the grid. Bycatches in this study were mainly evaluated for haddock, whiting and cod, i.e. not for all above mentioned bycatch species of concern in the Norway pout fishery. However, the experiments have shown that the bycatch of important human consumption species in the industrial fishery for Norway pout can be reduced substantially by inserting a grid system in front of the codend. The study also demonstrated that it is possible to retain a major part of the larger marketable fish species like whiting and haddock and at the same time maintain substantial reductions of juvenile fish of the same species. The study finally gave clear indications that further improvement of the selectivity is possible. This can be obtained by adjusting the bar distance in the grid and the mesh size in the selective window, but further research would be necessary in order to establish the optimal selective design.

The results reported in Kvalsvik *et al*. (2006) include results for more species of concern in the Norway pout fishery. They carried out experimental fishing with commercial vessels first testing a prototype of a grid system with different mountings of guiding panel in front of the grid and with different spacing (25, 22 and 19 mm) between bars, and then, secondly, testing if the mesh size in the grid section and the thickness of the bars influenced the selectivity of the grid system. Two different mesh sizes and three different thicknesses of bars were tested. Based on the first experiments, only a bar space of 22 mm were used in the later experiments. These showed respectively that a total of 94.6% (weight) of the bycatch species was sorted out with a 32.8% loss of the industrial target species, where the loss of Norway pout was around 10%, and respectively that 62.4% of the bycatch species were sorted out and the loss of target species was 22%, where the loss of Norway pout was around 6%. When testing selectivity parameters for haddock, the main bycatch species, the parameters indicated a sharp size selection in the grid system.

In conclusion, the older experiments indicate that there is no potential in using separator devices and square mesh panels. Recent and comprehensive experiments with grid devices indicate a loss of Norway pout at around 10% or less when using a grid with a

22–24 mm bar distance. It is also indicated that there is a considerable loss of other industrial species being blue whiting, Argentine and horse mackerel. A substantial bycatch reduction of saithe, whiting, cod, ling, hake, mackerel, herring, haddock and tusk has been observed. The reduction in haddock bycatch is, however, lowered by the presence of smaller individuals. The Danish experiment indicates that it is possible to retain larger valuable consume fish species by using a square mesh panel in combination with the grid. Selectivity parameters have been estimated for haddock, whiting and Norway pout. These can be used for simulation scenarios including estimates of the effect of changing the bar distance in the grid. Selectivity parameters for more bycatch species would be relevant. However, the grid devices have shown to work for main bycatch species. A general problem encountered by implementing sorting grids in industrial fisheries is the very large catches handled. Durability and strength of the grid devices used under fully commercial conditions are consequently very important and needs further attention. Furthermore, handling of heavy grid devices can be problematic from some vessels. Grid devices are, nevertheless, used in most shrimp fisheries, where catches often are large.

Sorting grids in combination with square mesh panels have been shown to reduce bycatches of whiting and haddock by 57% and 37%, respectively (Eigaard and Holst, 2004; Nielsen and Madsen 2006 (ICES CM 2006/ACFM:35); Eigaard and Nielsen, 2009).

The most recent study on bycatch reduction by use of selective devices in the Danish Norway pout fishery is published in Eigaard, Hermann and Nielsen, 2012. Here a lightweight sorting grid was developed to reduce bycatch in the Danish small-meshed trawl fishery (22 mm full mesh in the codend) for Norway pout in the North Sea. Experimental fishing with the grid demonstrated the possibility to capture Norway pout with only a minimum of unintended bycatch. Fishing with two different grid orientations, backwards and forwards-leaning, in distinct day and night hauls, resulted in an estimated release of between 88.4 and 100% of the total number of haddock (*Melanogrammus aeglefinus*) and whiting (*Merlangius merlangus*) entering the trawl. However, bycatch reductions were not significantly different between day and night or between grid orientations, indicating that the grid rejection of haddock and whiting is not influenced by fish behaviour. The loss of the target species, Norway pout, was low (between 5.6% and 13.7%) compared with the bycatch excluded, and clearly length dependent. Consequently, loss of target species would vary with the size structure of the population fished. Although results were not statistically significant, length-based analyses indicated that the grid rejection likelihood for particularly smaller Norway pout (<16 cm) was higher when fishing with the forwards-leaning grid during the night; this might be explained by behavioural and visual aspects of the fish-grid encounter process for Norway pout.

Discard of Norway pout in fisheries for consumption purposes

Discard levels of Norway pout in international fisheries are low as shown in Table 6 and Figure 10 of WD2 (Annex 3). It should be noted that Norway is not conducting discard sampling because of their discard ban, so the discard of Norway pout in Norwegian fisheries are not known. This is the case for both Norwegian fisheries for consumption purposes and small-meshed fisheries for reduction purposes. With respect to the latter there are in general no discarding in the small-meshed fisheries for reduction purposes in Denmark and Norway.

Norway pout is only caught in small-meshed fisheries for reduction purposes conducted by Denmark and Norway with typically 16–31 mm mesh size in the trawl codend (i.e. the DEF_16-31_0_0 or DEF_16-31_2_35 or DEF_16-31_X_X métiers) or in crustacean (shrimp and *Nephrops*) fisheries in the northern North Sea or in Skagerrak conducted by several countries. Table 6 in WD2 (Annex 3) gives an overview of discard of Norway pout by year, métier and country during the period 2002–2015 based on imported data from InterCatch August 2016. The discard data cover fisheries for human consumption purposes, which mainly are crustacean fisheries, as there is no discard of Norway pout in small-meshed fisheries (métiers) for reduction purposes conducted by Denmark and Norway. Other countries do not have small-meshed fisheries for Norway pout or do not sample them. Because of the discard ban there is no discard tabulated for the Norwegian fisheries. Figure 10 in WD2 (Annex 3) gives an overview of absolute (tons) and relative (%) proportion between discard of Norway pout in fisheries for human consumption purposes and the total landings of Norway pout in the small-meshed fisheries for reduction purposes (with no discard in the latter) divided by year in the period 2002–2014. The total landings data originate from the ICES evaluated total landings of Norway pout by year as presented in the September 2015 Norway pout assessment in the ICES WGNSSK Report 2015. As can be seen then discard rates are generally very low in years where there have been conducted significant Norway pout fishery.

3.5 Ecosystem drivers

Only limited knowledge is available on the influence of environmental factors, such as temperature, on the Norway pout recruitment.

The interplay between temperature-related processes and predation in determining age-1 recruitment strength between 1992 and 2006 was analysed for North Sea cod and Norway pout by Kempf *et al*. (2009). For this purpose, a predation impact index (PI) was calculated out of IBTS survey data. PI was assumed to depend on the abundance of the predators and on the spatial overlap between predator and prey populations. Generalized additive models (GAMs) were created with spawning–stock biomass (SSB) and sea surface temperature (SST) (SST) in the respective spawning and nursery areas and PI as explaining variables. Intraspecific SSB had no significant impact on recruitment during this time period for both species. SSTs during spring and PI explained the interannual variability of recruitment strength to a large extent (88% of the total variance for cod and 68% for Norway pout). The SST during spring determined the overall level of recruitment. At SSTs above a certain level, however, the effect on recruitment was no longer significant. In these temperature ranges, predation was the dominant effect. On this basis, Kempf *et al*. (2009) stated that the fate of North Sea cod and Norway pout stocks under global warming conditions will be strongly influenced by the status of the North Sea foodweb.

The data used for the analyses in Kempf *et al*. (2009) were IBTS survey data: North Sea wide (including the Skagerrak (ICES areas 4 and 3.a)), age-recruitment indices (RI) were calculated for cod and Norway pout from age-based, first-quarter IBTS data from 1992 to 2006 (ICES, 1999; see Kempf *et al*., 2009). According to Kempf *et al*. (2009) the Skagerrak was added because North Sea and Skagerrak subpopulations show high exchange rates and are treated as one stock in standard fish stock assessments. The average number of age-1 recruits caught in the first quarter in each ICES rectangle (0.58 latitude 18 longitude) was calculated for each species analysed whenever more than one haul was conducted in a certain year. Later, the average catch numbers were summed over all ICES rectangles to get an age-1 recruitment index for the North Sea and Skagerrak area. Because the coverage for ICES areas 4 and 3.a was complete in all years after 1991, the summation of the mean catches per ICES rectangle introduced no bias due to interannual changes in the number of ICES rectangles surveyed (Kempf *et al*. (2009).

It should again here be noted that the age–length keys of Norway pout survey data from the ICES IBTS surveys used in the study by Kempf *et al*. (2009) were not scrutinized and analysed on a disaggregated seasonal and area basis as the results from Lambert *et al*. (2009) revealed were necessary to obtain precise age readings and growth data and parameters on a spatio-temporal disaggregated basis for this Norway pout stock. This can also influence recruitment estimates.

According to Kempf *et al*. (2009) the IBTS age-1 recruitment index for Norway pout varied considerably between the years until the year 2000. From 2000 to 2006, the recruitment index was always at a low level and less variable than in previous time periods. The time-series of first-quarter SST north of 58.8◦N showed a significant increasing trend from 1994 onwards (Kempf *et al*., 2009). The SST value was outstandingly low in 1994 and extremely high in 1998. The SST during the second quarter also increased over the analysed time period; however, the trend was not found significant. As in the spawning and nursery areas of cod, the years 1992 and 1996 deviated from the general trend. SSTs during the third quarter were higher in the last third of the time-series than in the previous periods. The PI values were mainly in the range of 20 000 to 60 000. In single years, however, the index was <20 000 (in 1991) or >100 000 (in 2000). Kempf *et al*. (2009) did not find an obvious temporal trend. Furthermore, there was found no significant relationship between SSB in the year of birth and the IBTS age-1 recruitment index of the following year. High and low recruitment index values occurred at any part of the analysed SSB spectrum. SST in the first, second, and third quarters had no significant effect on recruitment strength of Norway pout in the models with SSB and SST as the only explaining variables. The SST in the 2nd quarter, however, had the strongest relationship with the recruitment index and was close to being significant (Kempf *et al*., 2009), however, the effect of second-quarter SST became significant when PI was added as an explaining variable. As with cod, the age-1 recruitment index of Norway pout was higher after the cold years (1994 and 1996) than after the warmer years. For temperatures >8.5◦C, no clear effect on the recruitment index could be recognized (Kempf *et al*., 2009). PI had a significant negative linear effect on the Norway pout recruitment index. The final model was able to explain the recruitment of Norway pout to a satisfying extent (Kempf *et al*., 2009). Both variables together explained 68% of the recruitment index from 1992 to 2006. A large part of the interannual variability, however, could not be resolved with PI and SST as explaining variables. The low recruitment in 2005, especially, could not be explained; this datapoint appeared as an outlier in the residual plot. When fitting the model without the recruitment index for 2005, the fit became better (R2 =0.75) and the effects of SST and PI on recruitment were more significant. No significant correlation was found between the explaining variables, and no significant autocorrelation of the model variables was detected at any lag. Also, the residuals were not distributed differently from a normal distribution (Kempf *et al*., 2009).

3.6 Stock assessment

3.6.1 Catch-quality, misreporting, discards

The industrial fishery for Norway pout in the North Sea is mainly carried out by Denmark and Norway in a mixed fishery using demersal trawls with small-meshed codend. Most of the fishery takes place at fishing grounds in the northern North Sea mostly at Fladen Ground and along the edge of the Norwegian Trench. Bycatch of other species is of a main concern in this fishery, and area closures have been implemented in both EU and Norwegian waters to reduce the bycatch of other gadoids and herring. In addition, selection grids have been used to reduce the bycatch of larger gadoids. Norway pout is landed for reduction purposes (fishmeal and fishoil), which makes it demanding to estimate the species composition in the landings; other species have been wrongly reported as Norway pout. The quality of the landings statistics in Norway and Denmark is described in WD3 and WD2 (Annex 3); the quality seems to be relatively constant during the last 20 years and of a higher quality than in the years before. The discard level of Norway pout in the North Sea fisheries is considered to be low (WD2, Annex 3).

3.6.2 Surveys

Description of catch, effort and research vessel data used in the assessment is given below and in Nielsen *et al*. (2016a; WD2, Annex 3), Nielsen (2016; WD1, Annex 3) and in the stock annex.

Survey tuning time-series used in the Norway pout assessment

Trawl survey index time-series of abundance of Norway pout by age and quarter are for the assessment period available from the ICES International Bottom Trawl Survey (IBTS Q1 and Q3) and the English Groundfish Survey (EGFS Q3 being a part of IBTS Q3) and the Scottish Groundfish Survey (SGFS Q3 being a part of IBTS Q3). An overview of the survey tuning time-series included used by year and age in the assessment during different assessment periods is shown in Table 3.6.2.1 below.

The survey trawl survey indices for Norway pout are in form of standard abundance and density indices estimated as the catch per unit of effort (cpue in number of fish per hour) by age for the international bottom-trawl surveys coordinated by ICES and conducted according to ICES standard survey and sampling design (www.ices.dk).

Table 3.6.2.1. Norway pout 4 and 3.aN (Skagerrak). Tuning fleets and indices used in the final 2004 benchmark assessment, in the 2005–2015 assessments, as well as in the 2016 assessment, compared to the 2003 assessment. Changes marked with grey.

		2003 ASSESSMENT	2004, 2005, April 2006 ASSESSMENT	Sept. 2006 ASSESSMENT	2007-15 ASSESSMENTS	2016- ASSESSMENTS
Recruiting season		3rd quarter	2nd quarter (SXSA)	3rd quarter (SMS); 2nd quarter (SXSA	2nd quarter (SXSA), autumn assessm.	3rd quarter SESAM
Last season in last year		3rd quarter	2nd quarter (SXSA)	3rd quarter (SMS); 2nd quarter (SXSA	2nd quarter (SXSA), autumn assessm.	3rd quarter SESAM
Plus-group		4+	4+ (SXSA)	None (SMS); 4+ (SXSA)	4+ (SXSA)	4+ (SESAM)
FLT01: comm Q1						
	Year range	1982-2003	1982-2004	1982-2004	1982-2004, 2006	NOT USED
	Quarter	1	1	1	1	
	Ages	1-3	1-3	1-3	1-3	
FLT01: comm Q2			NOT USED	NOT USED	NOT USED	NOT USED
	Year range	1982-2003				
	Quarter	2				
	Ages	1-3				
FLT01: comm Q3						
	Year range	1982-2003	1982-2004	1982-2004	1982-2004, 2006	NOT USED
	Quarter	3	3	3	3	
	Ages	0-3	1-3	1-3	1-3	
FLT01: comm Q4						
	Year range	1982-2003	1982-2004	1982-2004	1982-2004, 2006	NOT USED
	Quarter	4	4	4	4	
	Ages	0-3	0-3	0-2 (SMS); 0-3 (SXSA)	0-3 (SXSA)	
FLT02: ibtsq1						
	Year range	1982-2003	1982-2006	1982-2006	1982-2015	1982-2016
	Quarter	1	1	1	1	1
	Ages	1-3	1-3	1-3	1-3	1-3
FLT03: egfs						
	Year range	1982-2003	1992-2005	1992-2005	1992-2015	1992-2016
	Quarter	3	Q3 -> Q2	Q3 -> Q2	Q3 -> Q2	3
	Ages	0-3	0-1	0-1	0-1	0-1
FLT04: sgfs						
	Year range	1982-2003	1998-2006	1998-2006	1998-2015	1998-2015
	Quarter	3	Q3 -> Q2	Q3 -> Q2	Q3 -> Q2	3
	Ages	0-3	0-1	0-1	0-1	0-1
FLT05: ibtsq3		NOT USED				
	Year range		1991-2005	1991-2005	1991-2014	1991-2015
	Quarter		3	3	Q3	3
	Ages		2-3	2-3	2-3	2-3

1) The IBTS Q1 tuning fleet has remained unchanged compared to previous years' assessments and benchmark assessments.

It should be noted that in the 2014 IBTS Q1 survey, less hauls were conducted in the northern part of the North Sea than usual. This did not result in change in the log residual stock numbers, the log inverse catchabilities, and the weighting factors for computing survivors in the assessment for this survey.

2) The SGFS Q3 for age group 0 and 1 for the period 1998 and onwards has been used as tuning fleet in the assessment. The short time-series is due to the change in survey design for SGFS.

The SGFS data from 1998 onwards should be used with caution due to new survey design (new vessel from 1998 and new gear and extended survey area from 1999). The 0-group indices from this survey have accordingly not been used in the assessment tuning fleet for this survey prior to the 2004 benchmark assessment. The index for the 0-group from SGFS changed with an order of magnitude in the years after the change in survey design compared to previous years (Table 12.2.8, ICES, WGNSSK (2005)).

From 2009 onwards the SGFS changed its survey area slightly with a few more hauls in the northern North Sea and a few less hauls in the German Bight. This is not evaluated to influence the indices significantly as the indices are based on weighted subarea averages.

In 3rd quarter 2015 and 2016 test trials were conducted in the international third quarter IBTS with 15 minute duration hauls compared to 30 minute duration hauls. The new 15 minute test hauls have been included in the index calculation for 3rd quarter 2015 and 2016, and will potentially affect the Norway pout indices for the SGFS, the EGFS and the combined IBTS Q3 index. It has been necessary to include the 15 minute hauls in the SGFS 2015 and 2016 as extensive areas (of the total SGFS survey area) are only covered with this type of hauls. Analyses of this are ongoing and nothing conclusive is available at present concerning potential significant impacts of this on the indices. Preliminary analyses indicate no significant differences in catch rates of Norway pout between the 15 minute hauls and the 30 minute hauls in the SGFS; however, the variability is very high and there are only very few observations available.

For the September assessments up to and including 2015 the quarter 3 0-group and 1-group survey indices for SGFS is back-shifted to the final season of the assessment in the terminal year, i.e. to quarter 2 of the assessment year in order to include the most recent 0-group estimate in the assessment. From 2016, with use of the SESAM model including quarter 3 information in the terminal assessment year, this back shifting is not necessary.

3) The EGFS Q3 for age group 0 and 1 for the period 1992 and onwards has been used as tuning fleet in the assessment. The shorter time-series is due to the change in survey design for EGFS. Furthermore, there is a good argument for excluding the age 2–3 of the EGFS as the within survey correlation between the age groups 1–2 and 2–3 is very poor, while the within correlation between age groups 0–1 is good.

The EGFS data prior to 1992 should be used with caution as the survey design shifted in 1992. This change in survey design has until 2004 been accounted for by simply multiplying all indices with a factor 3.5 for all age groups in the years prior to 1992 in order to standardize it to the later indices. The EGFS survey indices for Norway pout has been revised in the 2004 assessment compared to the previous years' assessments for the 1996, 2001, 2002, and 2003 indices. In previous years' assessments (before 2004) the full EGFS survey time-series for all age groups have been included as an assessment tuning fleet.

In September 2015, the EGFS survey indices were revised to incorporate the relevant primes within the Norway pout area following the IBTS Manual (2015), i.e. in the selection of the prime stations to be included in the Norway pout index calculation. The revision is described in detail in an ICES working document to ICES WGNSSK 2015 (Silva, 2015). This has changed the EGFS indices for Norway pout for all years and ages since 1992. Especially, the indices for the 0-group have changed significantly without any obvious trends over time. However, the perception of the dynamics in the stocks (e.g. strong year classes as 0-group and also as older ages in the cohorts) seems not to have changed in relative terms. Consequently, there is consistency in this to the previous EGFS indices and in relation to the other survey indices also for Norway pout. The log inverse catchabilities in the September 2015 SXSA assessment have increased slightly for the EGFS in 2015 compared to previous years' assessments, while the weighting factors for computing survivors in the September 2015 SXSA assessment were quite similar to those from previous years' SXSA assessments. Also, this seems not to have affected the log residual stock numbers.

In 3rd quarter 2015 and 2016 test trials were conducted in the international third quarter IBTS with 15 minute duration hauls compared to 30 minute duration hauls. The new 15 minute test hauls have been included in the index calculation for 3rd quarter 2015 and 2016, and will potentially affect the Norway pout indices for the SGFS, the EGFS and the combined IBTS Q3 index. Only one 15 minute test haul was included in the EGFS 2015. Analyses of this are ongoing and nothing conclusive is available at present concerning potential significant impacts of this on the indices.

For the September assessments up to and including 2015 the quarter 3 0-group and 1-group survey indices for EGFS is back-shifted to the final season of the assessment in the terminal year, i.e. to quarter 2 of the assessment year in order to include the most recent 0-group estimate in the assessment. From 2016 with use of the SESAM model including quarter 3 information in the terminal assessment year this back shifting is not necessary.

4) Time-series for the combined IBTS Q3 survey are only available from 1991 and onwards. The IBTS Q3 for the period 1991 onwards has been included in the assessment. This survey has a broader coverage of the Norway pout distribution area compared to the EGFS and SGFS isolated. The 3rd quarter IBTS and the EFGS and SGFS are not independent of each other as the two latter is a part of the first. Accordingly, the below changes have been made for the survey tuning index series in the 2004 benchmark assessment.

As the combined IBTS Q3 survey index is not available for the most recent year (terminal assessment year) to be used in the September seasonal assessment it has been chosen to exclude the 0- and 1-group indices from the IBTS Q3 in order to allow inclusion of the 0- and 1-group indices from the SGFS and EGFS which are available for the most recent year in the September assessment. (Not relevant in relation to spring assessments conducted up to 2015). Accordingly, the IBTS Q3 tuning fleet for age 2 and age 3 has been included in the assessment as a new tuning fleet. The SXSA assessment model (used up to and including 2015) demands at least two age groups in order to run, which is one reason for including both age 0 and age 1 under the EGFS and SGFS tuning fleets and not including age 1 in the IBTS Q3 tuning fleet.

In 3rd quarter 2015 and 2016 test trials were conducted in the international third quarter IBTS with 15 minute duration hauls compared to 30 minute duration hauls. The new 15 minute test hauls have been included in the index calculation for 3rd quarter 2015 and 2016, and will potentially affect the Norway pout indices for the SGFS, the EGFS and the combined IBTS Q3 index. Analyses of this are ongoing and nothing conclusive is available at present concerning potential significant impacts of this on the indices.

Revision of assessment tuning fleets (survey cpue data and commercial fishery cpue data) in the 2004 benchmark assessment

Revision of the Norway pout assessment tuning fleets was performed during the 2004 benchmark assessment. The background for this, the results, and the conclusions from the analyses in relation to this are described in the stock annex (stock quality handbook) as well as in the benchmark assessment in the working group report from 2004.

Revision of the Norway pout assessment tuning fleets during benchmark assessment have been based partly on cohort analyses and analyses of correlations within and between the different tuning fleet indices by age group, as well as on the results from a row of exploratory assessment runs described under Section 12.3 of the 2004 benchmark assessment (ICES, WGNSSK (2005)) which analyses the performance of the different tuning fleets in the assessment. The exploratory assessment runs also give indications of possible catchability patterns and trends in the fishery over time within the assessment period. The analyses of the tuning fleet indices are presented in the benchmark assessment 2004 (ICES, WGNSSK (2005) Figures 12.2.3–12.2.8 and Tables 12.2.9–12.2.12).

Overview of Norway pout distribution and density patterns from IBTS Q1 and Q3 surveys

In Nielsen (2016; WD1, Annex 3) and Nielsen *et al*. (2016a; WD2, Annex 3) a comprehensive overview and mapping of Norway pout distribution and density patterns in the North Sea and Skagerrak areas are presented and evaluated based on ICES IBTS Q1 and Q3 surveys.

Summary of Norwegian survey

Annual shrimp swept-area surveys have been conducted by the Institute of Marine Research since 1984 in Skagerrak and the Norwegian Deep in the eastern side of the Norwegian trench in the North Sea. The main objective of the survey is to monitor abundance and distribution of the northern shrimp (*Pandalus borealis*) stock. In addition to northern shrimp, the catch of fish, Norway lobster and sea cucumber have been sorted to species where the total weight and abundance, the individual length and/or weight have been recorded for each species. The depth (100–550 m) and geographical distribution of the trawl positions of the shrimp survey do not overlap with the positions covered by the International Bottom Trawl Surveys organized by ICES; however, Norway pout is a very common species in the catches for both the IBTS surveys and the Norwegian trawl survey despite the non-overlapping survey areas.

Johnsen and Søvik (2016; WD5, Annex 3) analyse the shrimp survey data with the purpose of establishing an additional fishery-independent survey time-series that may be used as a future input in the stock assessment of Norway pout in the Skagerrak and North Sea. Despite the shortcomings in the analyses caused by the lack of age reading and short time-series, the results clearly indicate that the survey estimates are in line with the IBTS survey time-series. Therefore, the full survey time-series (from 1984) should be estimated when data are available, and more advanced methods used to estimate ages based on length distributions, before the survey time-series can be tested as an input to the Norway pout stock assessment.

3.6.3 Mortality

The ICES inter-benchmark assessment in spring 2012 (IBPNorwayPout, ICES, 2012c) introduced revised estimates of natural mortality and maturity-at-age used in the Norway pout stock assessment. The background and rationale behind the revision of the natural mortality and maturity parameters is described in the IBPNorwayPout report (ICES, 2012c) and primary literature (e.g. Nielsen *et al.*, 2012; Lambert *et al.*, 2009; ICES, WGSAM 2011), as well as summarised below. A follow up on this analysis is presented in Nielsen (2016; Section 5 in WD1, Annex 3) with the same conclusions.

Instead of using a constant natural mortality set to 0.4 for all age groups in all seasons as used in the previous assessments, variable natural mortality between ages have been introduced in the 2012 inter-benchmark assessment and used in all following assessments. The revision of the natural mortality parameter was based on results in Nielsen *et al.* (2012) and the ICES, WGSAM 2011 multispecies assessment report. It should be noted that natural mortality levels by age and season used in the stock assessment reflect the predation mortality levels estimated for this stock in the multispecies stock assessment performed by ICES. The revised values are shown in Table 3.6.3.1.

Table 3.6.3.1. Norway pout 4 and 3.aN (Skagerrak). Mean weight-at-age in the stock, proportion mature and natural mortality used in the assessment from 2012 onwards. (Inter-Benchmark 2012 assessment scenario 2 settings).

Age	Weight (g)				Proportion mature	M
	Q1	Q2	Q3	Q4		Quarterly
0	-	-	4	6	0	0,29
1	9	14	28	28	0,2	0,29
2	26	25	38	40	1	0,39
3	43	38	51	58	1	0,44

Evaluations performed in the IBPNorway pout

The ICES IBPNorwayPout inter-benchmark exercise evaluated alternative biological inputs in the stock assessment for natural mortality, sexual maturity and growth (mean weight-at-age in the stock) for the Norway pout stock in the North Sea and Skagerrak. The natural mortality, maturity, and mean weight used in the scenarios evaluated in the benchmarking process originate from results published in Nielsen *et al.* (2012), Lambert *et al.* (2009), Sparholt *et al.* (2002a,b), as well as from the multispecies assessment working group ICES, WGSAM 2011. In particular, natural mortality estimates for Norway pout originating from the key run of the multispecies SMS model (2011) were applied. Five scenarios were considered, a Baseline Scenario following the current assessment approach and four additional scenarios which explored alternative biological inputs as presented in Table 3.6.3.2 and summarized below.

Baseline:

The May 2011 Norway pout assessment was selected as the Baseline assessment. The settings of the Baseline were constant natural mortality by quarter and age fixed at 0.4, 10% maturity for the 1-group and 100 % mature for the 2+ group, and constant MWA assumed in stock. The following alternative scenarios were tested in the benchmark exercise:

Scenario 1:

Natural mortality (M) change: Average Z at-age used as a proxy for M, computed for ages 1–3 in the years 2004, 2005, 2007 and 2008 (years with low fishing mortality) based on Q1 IBTS ICES NP indices from the standard ICES NP index area (calculated from Q1-Q1 cohorts as averages for these four years based on the approach in Nielsen *et al*. (2012, Figure 1). Yearly Ms were divided by 4 to obtain quarterly Ms, and M-at-age 0 was set equal to that for age 1. In Scenario 1 the same maturity ogive and mean weight-at-age was used as in the Baseline assessment.

Scenario 2:

Natural mortality (M) change: Same M inputs as Scenario 1. Maturity ogive change: Maturity-at-age 1 was set to 0.2 from Lambert *et al*., 2009, Figure 4. Maturity-at-age 2 was set to 100%. Mean weight-at-age in stock (MWA) change: The settings were based on results from commercial fishery during the period 1983 to 2006 as presented in Lambert *et al*. (2009, Figure 8.). The long-term trends in MWA were calculated for the period 1983 to 2011 by quarter and area for the Danish commercial fishery and compared to Lambert *et al*. (2009) Figure 8 values and were found to be consistent. The revised Mean Weight-at-Age (MWA) in the stock used in the benchmark assessment were for the 1-, 2- and 3- groups taken as the long-term averages from the commercial data. Data for MWA by quarter for age 0 were kept constant as used in the Baseline. MWA was recorded from commercial fishery catch data, but not during the IBTS, from which only length data are available.

Scenario 3:

Natural mortality (M) change: Average Z at-age (being a proxy for M) for ages 1–3 for the full year range 1983–2005 from Q1-Q1 IBTS revised indices from Nielsen *et al*. (2012) Figure 1 (as presented in Table 3). Yearly Ms divided by 4 to obtain average quarterly M's. M-at-age 0 set equal to that for age 1. Maturity ogive change and mean weight-at-age (MWA) change: Same as in Scenario 2.

Scenario 4:

Natural mortality (M) change: M1+M2 from the multispecies SMS model from 2011 key run presented in the ICES, WGSAM 2011 Report. Averages of the SMS estimates of quarterly M1+M2 have been used for the full year range used in the SMS key run (2011). Maturity ogive change and mean weight-at-age (MWA) change: Same as in Scenario 2.

Table 3.6.3.2. Norway pout 4 and 3.aN (Skagerrak). Mean weight-at-age in the stock, proportion mature and natural mortality used in the assessment. Baseline settings and Scenario 1–4 settings for population dynamics parameters. New parameter settings are in red.

Baseline

Age	Weight (g)				Proportion mature	M	M values evaluated (Exploratory run)
	Q1	Q2	Q3	Q4		Quarterly	
0	-	-	4	6	0	0.4	0.25
1	7	15	25	23	0.1	0.4	0.25
2	22	34	43	42	1	0.4	0.55
3	40	50	60	58	1	0.4	0.75

Scenario 1

Age	Weight (g)				Proportion mature	M
	Q1	Q2	Q3	Q4		Quarterly
0	-	-	4	6	0	0.29
1	7	15	25	23	0.1	0.29
2	22	34	43	42	1	0.39
3	40	50	60	58	1	0.44

Scenario 2

Age	Weight (g)				Proportion mature	M
	Q1	Q2	Q3	Q4		Quarterly
0	-	-	4	6	0	0.29
1	9	14	28	28	0.2	0.29
2	26	25	38	40	1	0.39
3	43	38	51	58	1	0.44

Scenario 3

Age	Weight (g)				Proportion mature	M
	Q1	Q2	Q3	Q4		Quarterly
0	-	-	4	6	0	0.26
1	9	14	28	28	0.2	0.26
2	26	25	38	40	1	0.54
3	43	38	51	58	1	0.71

Scenario 4

Age	Weight (g)				Proportion mature	M
	Q1	Q2	Q3	Q4		Quarterly
0	-	-	4	6	0	0.65
1	9	14	28	28	0.2	0.41
2	26	25	38	40	1	0.35
3	43	38	51	58	1	0.29

Results of the evaluations performed in the IBPNorway pout

The change in natural mortality in Scenario 1, where survey-based average Zs in the four years with very low or no fishing mortality has been used as a proxy for M, resulted in applying M-values of similar magnitude by age and quarter (around 0.3 for age 0 and 1 and 0.4 for age 2 and 3) as the age and quarter invariant values used in the Baseline assessment (0.4 by age and quarter). The total mortality on the cohort (and the age-specific variation herein) determines the recruitment, the number of survivors and the biomass. The slightly lower natural mortality for the 0-group fish, for which the fishing mortality was very low, and the slightly higher natural mortality for the oldest fish (age 3 at 0.44) resulted in a slightly lower total-stock biomass (TSB) and R and nearly the same SSB and F_{bar}(1–2) as the Baseline. This was expected given these modest age-specific changes in M between Baseline and Scenario 1. The maturity ogive in Scenario 1 was the same as the Baseline with only 10% of age 1 mature, resulting in SSB similar to the Baseline. Because the catch-at-age data used in the Baseline and in all tested scenarios were the same, and because natural mortality on the main fished part of the population, i.e. age 1–3, was slightly lower for age 1 at 0.29 and slightly higher for age 3 at 0.44 in Scenario 1 (and 2)), this resulted in the recruitment being a little bit lower while fishing mortality was similar comparing Scenario 1 (and Scenario 2) with the Baseline. The same perception of the stock dynamics (fluctuations) over time was observed for Scenario 1 and the Baseline.

Scenario 2 had the same natural mortality change used as in Scenario 1 but the maturity ogive and MWA vector were different. The maturity ogive was changed to 20% mature of the 1-group, and the revised MWA in the stock was applied, obtained from long-term averages measured from the commercial fishery catch. The changes in MWA were minor compared to the Baseline and did not have much impact. The change in the maturity ogive, where 20% are mature compared to value of 10% in the Baseline resulted in a higher SSB in Scenario 2 compared to the Baseline (and Scenario 1) as would be expected. The same trends in R and TSB as well as F were observed in Scenario 2 as in Scenario 1 and the reason for this was the same as described above under Scenario 1. Also recruitment was somewhat lower under Scenario 2. In combination, higher SSB and lower R under Scenario 2 implied a lower overall recruitment rate (R/SSB). Overall, the same perception of the stock dynamics (fluctuations) over time was observed for Scenario 2 and the Baseline.

Scenario 3 operated with bigger changes in mortality by age compared to the baseline. In this scenario the M-value for the 0- and 1-groups was around 0.25 and the M for the older age groups were significantly higher (around 0.55 for age 2 and 0.7 for age 3). The same maturity ogive and MWA vector was in Scenario 3 as was used in Scenario 2. Much greater mortality on the old, large fish together with fishing mortality resulted in a high total mortality on the older fish, and consequently, there needed to be more recruits to sustain this mortality (as the same number of fish was caught in all scenarios). This resulted in higher R, and a much higher TSB and SSB, and a perceived lower fishing mortality. Because of the significant change in M in this scenario the stock dynamics and perception of the stock and recruitment for Scenario 3 were different over time compared to the Baseline.

Scenario 4 used the multispecies model estimates of M where the quarterly mortality was higher on the young fish and lower on the older fish, i.e. around 0.65 for age 0, 0.4 for age 1, 0.35 for age 3 and 0.3 for age 3. This resulted in similar TSB and SSB as the Baseline but a perception of slightly higher recruitment and fishing mortality.

Conclusions on the evaluations performed in the IBPNorway pout

The independent reviewers considered that the new values for biological inputs constituted an improvement to the assessment of Norway pout and they supported the use of Scenario 2 as the new Baseline for the stock assessment. They expressed some concern regarding the estimation of mortality rates from survey data without accounting for the survey catchability at-age. Ideally natural mortality should be estimated within the stock assessment model simultaneously with estimates of survey catchability, but in most cases the data are inadequate to do this. Evidence of density-dependence in Norway Pout mortality, growth and maturation rates suggested that using fixed estimates in stock assessments could lead to biases and this was worthy of further investigation. The reviewers noted that the stock–recruit scatter was relatively uninformative but considered that the values being used for biological reference point should still apply. Consideration could also be given to a higher target escapement level given the importance of Norway Pout as a forage species in the ecosystem.

The Benchmark group concluded that revisions to natural mortality, maturity and mean weight-at-age should be included in the final benchmark assessment based on the approach in Lambert *et al*. (2009) and Nielsen *et al*. (2012). It was not recommended that Z values be used as proxies for M values for the full year range since 1983 (Scenario 3) as this average included fishing mortality which, especially in the early part of the period, was relatively high, i.e. this gave a biased overestimation of M. Both Scenarios 2 and 4 were found worthy of further consideration in the Benchmark. The results of Scenarios 2 and 4 were not significantly different from the baseline scenario, and both scenarios gave the same perception of the stock dynamics (fluctuations) over time was observed for the baseline.

The population dynamic parameters and approach used in Scenario 2 have been documented in Nielsen *et al*. (2012) and in Lambert *et al*. (2009). SMS estimates of mortality on A1 were higher than those based on Z estimates from the IBTS index. This difference in perception could occur if the catchability on A1 was low. The above cited papers investigate and argue that the catchability of the 1-group Norway pout was not lower than for the older age groups (although this was somewhat contrary to the catchability estimates at-age for IBTS coming out of both the Baseline and the Scenario 2 SXSA assessment model estimates), and that there was no age-specific migration out of the assessment area (being the whole North Sea and Skagerrak-Kattegat).

Scenario 4 used results of M from the SMS model assessment which had a number of characteristics and assumptions as well. The SMS assumed constant residual mortality-at-age (M1), i.e. natural mortality due to other reasons than predation. This was in contradiction to potential spawning mortality as discussed in Nielsen *et al*. (2012) which would result in M increasing with age. Also, the SMS smoothed mortality out between ages 1–3, i.e. did not fully consider potential differences in natural mortality between these ages, because the model used rather wide size intervals in its prey–predator preference model (ICES, 2011b; pers. comm. Morten Vinther and Anna Rindorf, DTU Aqua, March 2012). This meant that the mortalities between age 1, age 2 and age 3 tended to be equalized in the model. In the SMS a main predator on Norway pout age 1 to age 3 was saithe, and the SMS assessment results are sensitive to biomass estimates of saithe in the North Sea. The SMS used the saithe (predator) biomass estimates from the ICES WGNSSK single-stock assessment (ICES, WGNSSK 2011), and this assessment was very uncertain. Consequently, the SMS natural mortality estimates on Norway pout were dependent on uncertain assessment estimates of saithe in the North Sea which also influenced age-specific mortalities on Norway pout. Compared with the analysis of IBTS survey data, SMS estimates of total yearly M (and also Z) were higher for age 0 and 1 and lower for age 2 and 3 Norway pout (Nielsen *et al*., 2012). Even if the catchability in the surveys was lower for age group 1, then it was difficult to explain the lower mortalities estimated by the SMS for age 2 and age 3 compared to the observed age 2 and age 3 survey based mortality estimates. In Nielsen *et al*. (2012) it was argued that migration in or out of the area was very unlikely, so the lower estimates of Z from SMS at-age 2 and especially age 3 compared to estimates from the IBTS data (Nielsen *et al*., 2012) were difficult to explain.

In conclusion the benchmark group agreed that Scenario 2 was preferred based on the available information, and recommended Scenario 2 be used as the new baseline assessment for the Norway pout stock from 2012 onwards.

Natural mortalities from multispecies assessments

In Nielsen (2016; Figure 26 in WD1, Annex 3) the total mortality (Z) and natural predation mortality (M2) of Norway pout by age for the period 1983–2013 is shown as estimated by the SMS model in the 2013 baseline run. The yearly values are shown, but the SMS does also estimate quarterly mortalities. The natural mortalities, M, from the SMS run is variable by year and quarter. If the variable natural mortality values from SMS are used in the Norway pout assessment the following points should be taken into consideration:

a) The SMS does not take into account likely spawning mortality (see also the 2012 inter-benchmark conclusions above).

b) The natural mortalities of Norway pout from SMS are very dependent on uncertain predator assessment biomasses (both from single-species assessments and multispecies assessments), especially for saithe, but also for Northeast Atlantic mackerel (see also the 2012 inter-benchmark conclusions above). Furthermore, the migration patterns (and extension of distribution) of Northeast Atlantic mackerel into the North Sea is very variable between years and over the whole period, and this is not well estimated.

c) The SMS is not updated every year and the last SMS key run is for 2013. Accordingly, M values for Norway pout need to be assumed or taken as constant mean averages anyway in the last three terminal assessment years (2014–2016). Accordingly, we will not have yearly and quarterly variable values available anyway from SMS on M to include into the SXSA for the latest three years which are the most important years in assessment and forecast context. The SMS key runs are made every third to fourth year, and the experience is that the M values changes drastically every time a key run is made (e.g. from the 2011 key run to the 2013 key run). This means that we have to assume the M values anyway for the recent and most important years in the assessment (as it is only three age classes that are important in the assessment), and that the M values will change every time a new SMS key run is made.

d) If we change the absolute biomass / abundance of Norway pout in the single-stock benchmark assessment significantly then the M values for Norway pout in the SMS are "not correct" as the SMS estimates and assessment of Norway pout biomass is adjusted to fit the single-stock assessment biomass ("adjusted to match the single-stock assessment").

In general, the SMS estimates the natural mortality higher for 0- and 1-group Norway pout compared to the estimates for the same age groups in Nielsen *et al*. (2012). However, this is not the case in the period 1990–2000 where the estimates of M for age 0 and 1 are at the same level in the SMS and in Nielsen *et al*. (2012). The natural mortality is lower in the SMS for age 2 and 3 compared to the estimates for the same age groups in Nielsen *et al*. (2012). This difference is due to SMS not taking into account potential spawning mortality increasing the M with age as estimated in Nielsen *et al*. (2012).

In the Ecopath with Ecosim Model (EwE) the total mortality and the predation mortality (M2) for Norway pout is not estimated by age group but combined for all age groups (and combined for juvenile and adult) of Norway pout. In Nielsen (2016; Figure

27 in WD1, Annex 3) the yearly total mortality (Z) and the yearly predation mortality (M2) from the EwE is shown for the period 1991 to 2013 based on the latest EwE key run in 2015. The values are total for all age groups and both juveniles and adults of Norway pout.

The EwE estimates the predation mortality rather high at the start of the period from 1991–2013 at levels around 2, but with a decreasing tendency over time to a level around 1.5 at the end of the period. The latter level is in accordance with the general level of M2 in the SMS and in Nielsen *et al*. (2012).

Many of the above aspects mentioned in relation to the SMS is also the case with respect to EwE estimates of natural mortality (predation mortality) for Norway pout.

Previous benchmark analyses of natural mortality

Possible revision of the natural mortality parameter in the assessment was also evaluated in the September 2006 benchmark assessment in response to the wish from ACFM RG 2006 on a separate description of natural mortality aspects for Norway pout in the North Sea. In summary no conclusions could be reached from the exploratory runs then using different natural mortalities from previous primary literature (Sparholt *et al*., 2002a,b; ICES, 2006) as the mortality between age groups was contradictive and inconclusive between periods (variable) from the different sources used showing different trends with no obvious biological explanation. On that basis it was decided in the 2006 benchmark assessment that the final assessment continues using the constant values for natural mortality-at-age. The background for these conclusions and the benchmarking in 2006 was that exploratory runs of the SXSA model was presented in the 2001 and 2002 assessment reports as well as in the 2004 and 2006 assessments (Norway pout benchmark assessments) with revised input data for natural mortality by age based on the results from two papers presented to the working group in 2001, (later published in Sparholt *et al*., 2002a,b) as well as natural mortality estimates from the North Sea MSVPA model (ICES SGMSNS 2006) in the 2006 assessment (ICES CM 2006/ACFM:35). These revised natural mortalities were given in the 2004 ICES, WGNSSK Report (ICES, WGNSSK (2005); ICES CM2005/ACFM:07) and the ICES, WGNSSK 2006 report including the described inter-benchmark assessments. Furthermore, estimates of total mortality based on the SURBA assessment model estimates (2005 SURBA run for Norway pout, ICES C.M. 2006/ACFM:35) using all survey time-series included in the baseline assessment (ICES CM 2007/ACFM:18 and 30) covering the period 1983–2005 indicated that for the period up to 1990–1995 the Z estimated from SURBA and Sparholt *et al*., 2002a,b was at the same level for both the 1–2 group and 2–3 group, and there also seems to be age specific differences in Z. In the period from 1995 and onwards the Z-estimates from SURBA were lower compared to the constant M values obtained from Sparholt *et al*., 2002a,b. In later years from 2002–2003, the SURBA estimates of Z increased again compared to the period 1995–2001. In conclusion, the exploratory runs gave very much similar results and showed no differences in the perception of the stock status and dynamics. Previous evaluation of total mortality Z, in years where fishing mortality has been very low and where total mortality accordingly approximately equals natural mortality, was conducted and presented in the September 2007 WGNSSK Report (ICES CM 2007/ACFM:18 and 30, Table 5.2.12). This evaluation was based on catch curve analysis on recent (IBTS Q1 and Q3) survey estimates for Norway pout. The results indicated somewhat different levels of Z between different survey time-series mirroring the results from the 2006 benchmark assessment.

3.6.4 Weights, maturity, growth

Maturity

According to Lambert *et al*. (2009) and Nielsen *et al*. (2012), 20% of age 1 is estimated mature and is included in the SSB. Therefore, the recruitment in the year after the assessment year influences the SSB already in the following year and very much in the second year. Recruitment is highly variable and influences SSB and total-stock biomass (TSB) rapidly because of the short lifespan of the species. Consequently, the population dynamics of Norway pout in the North Sea and Skagerrak are very dependent on changes caused by spawning and recruitment variation as well as variation in predation (or other natural) mortality, and less by the fishery (Nielsen *et al*., 2012; Lambert *et al*., 2009; Sparholt *et al*., 2002a, 2002b; Lambert *et al*., 2009).

The ICES inter-benchmark assessment in spring 2012 (IBPNorwayPout, ICES, 2012c) introduce revised estimates of maturity and natural mortality-at-age used in the Norway pout stock assessment. The background and rationale behind the revision of the natural mortality and maturity parameters is described in the IBPNorwayPout report (ICES, 2012c) and primary literature (e.g. Nielsen *et al*., 2012; Lambert *et al*., 2009; ICES, WGSAM 2011)). See above conclusions from this in Section 3.6.3. A follow up on this analysis is presented in Nielsen (2016; Section 3 in WD1, Annex 3) with the same conclusions.

The same proportion mature and natural mortality are used for all years in the assessment. The proportion mature used is 0% for the 0-group, 20% of the 1-group and 100% of the 2+-group independent of sex. The revisions of the maturity ogive which have been implemented in the 2012 inter-benchmark assessment and following assessments, based on results from Lambert *et al*. (2009), indicate that the maturity rate for the 1-group is close to 20% in average (varying between years and sex) with an increasing tendency over the last 20 years. Furthermore, the average maturity rate for 2- and 3-groups in 1st quarter of the year was observed to be only around 95% as compared to 100% used in the assessment.

Weight and growth

Mean weight-at-age in the stock

The inter-benchmark assessment in spring 2012 (IBPNorwayPout, ICES, 2012c) introduce revised estimates of mean weight-at-age in the stock used in the Norway pout assessment. The background and rationale behind the revision of mean weight-at-age in the stock is described in the IBPNorwayPout report (ICES, 2012c) and primary literature (e.g. Lambert *et al*., 2009). See above conclusions from this in Section 3.6.3. A follow-up description of this analysis is presented in Nielsen *et al*. (2016a; Section 5 in WD2, Annex 3) with the same conclusions.

The same mean weight-at-age in the stock is used for all years, and mean weight-at-age in catch is partly used as estimator of weight in the stock. This has resulted in slightly changed levels of constant mean weight-at-ages in the stock which have been calculated partly from long-term averages of mean weight-at-age in the catch. No major revision of mean weight-at-age in the stock has been performed compared to the values used in previous assessments. The estimation of mean weights-at-age in the catches and the used mean weights in the stock in the assessment is described in Nielsen *et al*. (2016a; WD2, Annex 3) and in the stock annex.

The revised Mean Weight-at-age (MWA) in the stock used in the benchmark assessment were for the 1-, 2- and 3- groups taken as the long-term averages from the commercial data. Data for MWA by quarter for age 0 were kept constant as used in the Baseline. MWA was recorded from commercial fishery catch data, but not from the IBTS, from which only length data are available. The revised MWA in the stock was applied in assessment scenario runs as obtained from long-term averages measured from the commercial fishery catch. The changes in MWA were minor compared to the Baseline and did not have much impact on the assessment results.

Mean weight-at-age in the catch

The mean weight-at-age in the catch is based on observations, i.e. samplings from commercial fishery (see Nielsen *et al*., 2016a; Sampling Section A.3 in WD2, Annex 3), since 1984. Mean weight-at-age in the catch is estimated as a weighted average of Danish and Norwegian data. Mean weight-at-age in the catch is shown in the yearly assessment reports including the historical levels, trends and seasonal variation in this. Mean landings weight-at-age from Danish and Norwegian fishery from 2005–2008 as well as for 2011 are uncertain because of few observations. Missing values have been filled in using a combination of sources, values from 2004, from adjacent quarters and areas, and from other countries within the same year, for the period 2005–2008, and in first half year 2010, and for 2011 there has also been used information from other quarters. Also, mean weight-at-age information from Norway has in 2011 involved survey estimates. The assumptions of no changes in weight-at-age in catch in these years do not affect assessment output significantly because the catches in the same period were low. Mean weight-at-age data are available from both Danish and Norwegian fishery in 2009, second half 2010, second half 2011, second half 2012, and all of 2013, 2014 as well as in 2015 and 2016.

The mean weight-at-age used in the commercial tuning fleet by quarter for the period 1983–2006 in the assessments from 2006–2015 (where the commercial tuning fleet has been used in the assessment) are shown in the yearly assessment reports. It appears that mean weight-at-age in the commercial tuning for fleet 1 for age group 2 in 4th quarter of the year is very low.

As the abundance (number of individuals) in the tuning indices as well as the number of fish in the catches by age group (catch numbers) are calculated by raising the weights of the samples with the total catch weights, the catch in numbers and the numbers of individuals in the indices are influenced directly by the mean weight-at-age estimates used. Accordingly, if the mean weight-at-age is too low then this will positively bias the abundance estimates used as input in the assessments (numbers-at-age in catch and cpue in the indices).

WD6 in Annex 3 describes the model used to calculate mean weights-at-age the catches for the purposes of providing a catch forecast. See also Section 3.7.

3.6.5 Assessment model

A seasonal extension to the State–space Assessment Model (SAM) was evaluated during this benchmark for Norway pout and compared with the model previously used (Seasonal XSA). This new model (SESAM) estimated very similar trends in SSB and fishing mortality compared to SXSA. The SESAM model was preferred by the group due to its ability to incorporate process and observation error and estimate uncertainties in all quantities, including the forecast.

The method is described in detail in WD6 (Annex 3), and the source code is available online at www.stockassessment.org under "NorPoutBench2016".

In brief, the model is the same as the SAM model, except that the time-step used is one quarter of a year rather than a full year. As in the SXSA, recruitment is assumed to occur in quarter 3 only. The logarithm of the fishing mortality-at-age and quarter is assumed to follow a multivariate random walk with lag 4 and correlated increments, i.e. the log F-at-age in a given quarter is given by the log F-vector in the same quarter one year earlier plus a correlated noise term with mean zero.

The observation equations in SESAM are also extended to deal with zero observations (both surveys and catches), which are usually treated as missing values in SAM. This is done by introducing a detection limit for each fleet, and defining the likelihood of a zero observation to be the probability of obtaining a value less than the detection limit. The detection limit is set to 0.5 times the smallest positive observation by fleet.

A special option was included to down-weight the influence of large jumps in log F on the estimated random walk variance due to periods where the fishery was closed. This option reduced the estimated log F process variance considerably.

The data used were those used in the May 2014 assessment of Norway pout. Nine different configurations of the SESAM model and the input data were examined. These are reported in WD6 (Annex 3). In summary, these cases were:

1) Base run. Commercial cpue series omitted. Detection limit set to 0.5 times the smallest positive observation by fleet. Excluding the years 2005–2008 from the log F random walk variance estimation.
2) As the base run but with commercial cpue series included.
3) As the base run but detection limit set to 0.99 times the smallest positive observation by fleet.
4) As the base run but detection limit set to two times the smallest positive observation by fleet.
5) As the base run but excluding data from 1983 and 1984.
6) As the base run but with 0.5 times the natural mortality.
7) Final run. As the base run but excluding data from 1983.
8) As the base run but excluding data from 1983, 1984, and 1985.
9) As the base but using same F RW variance in all years.

The group recommend to omit the commercial cpue series, because this dataseries is not independent from the catches, although this is assumed by the model, and independent survey data are available, which is to be preferred. The assessment performed well when leaving out the commercial cpue, and the observed trends were similar.

Run 2 and 3 examined the sensitivity of the model to the assumed detection limit, and it was found to be quite insensitive.

Run 5, 7, and 8 examined how the earliest datapoints affected the assessment, because there were concerns about their accuracy. These concerns regarded correct species identification of the catches and missing observations of weight-at-age in the catches in 1983.

For these reasons the group recommend run 7, which excludes data from 1983, and the figures in the following are from run 7.

The residuals (Figure 3.6.5.5) did not exhibit signs of systematic errors, and the retrospective diagnostic looks acceptable (Figure 3.6.5.6). A comparison of predicted vs. observed total catch weight by quarter and year is shown in Figure 3.6.5.7.

The minimum of the estimated SSB time-series by quarter, i.e. the B_{lim}, is given in Table 3.6.5.1. Table 3.6.5.2 summarises recruitment, SSB and F(1–2).

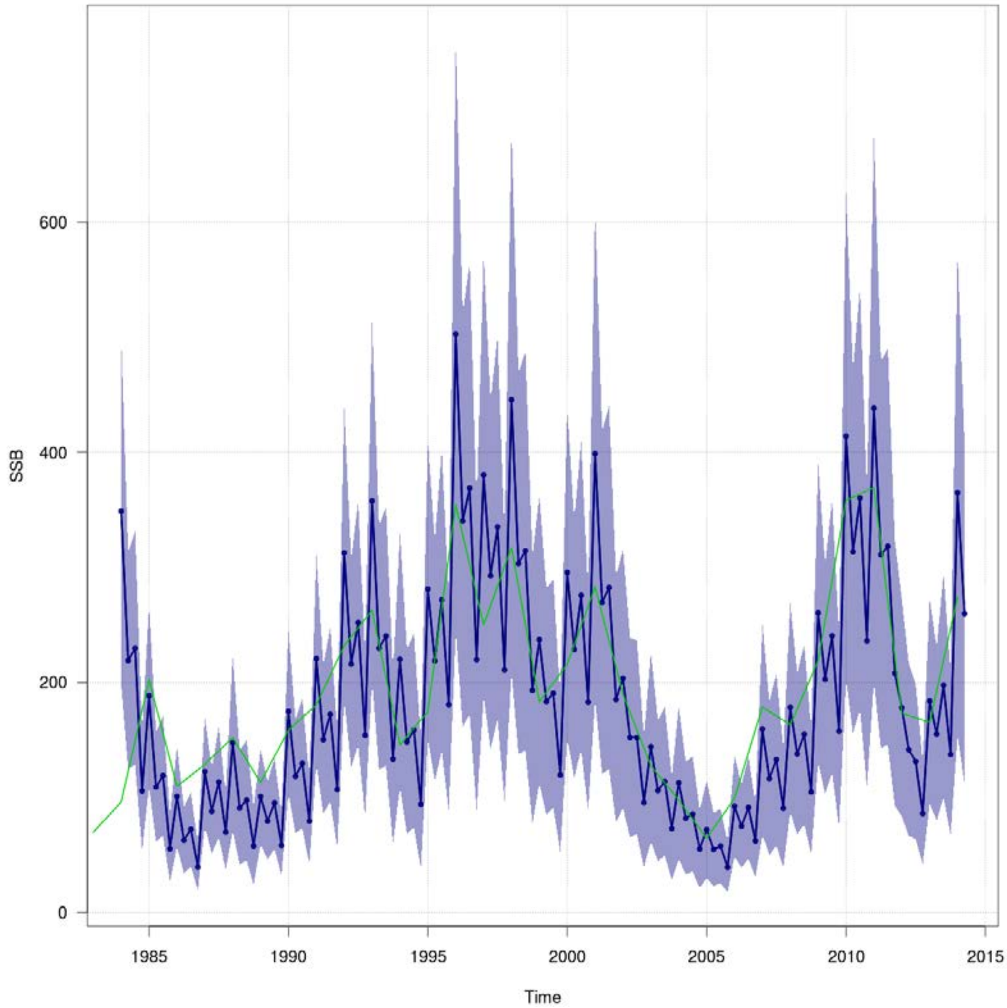

Figure 3.6.5.1. Quarterly estimated SSB and confidence interval from SESAM (blue) and SXSA (green, quarter 1 only; connecting lines are interpolations).

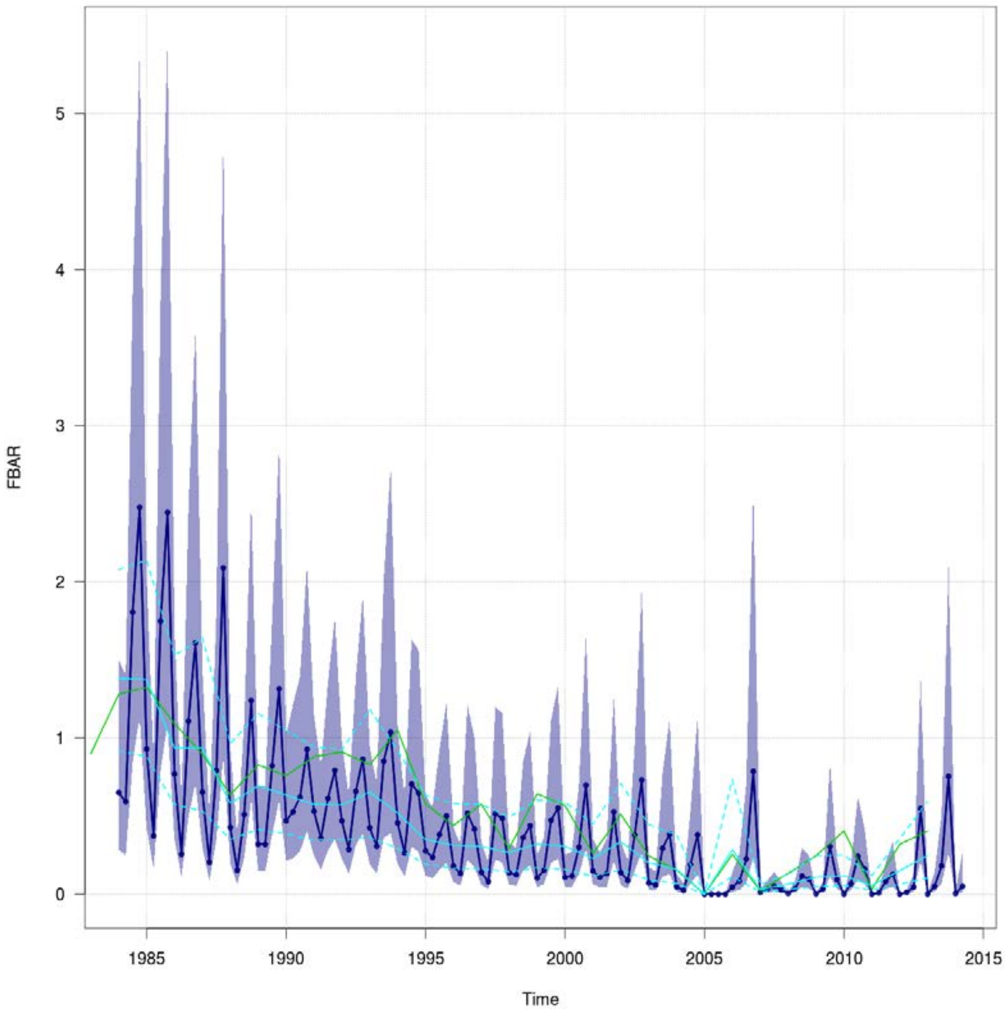

Figure 3.6.5.2. Average fishing mortality (ages 1–2). Blue is quarterly values from SESAM, cyan is the yearly average from SESAM, green is yearly average from SXSA.

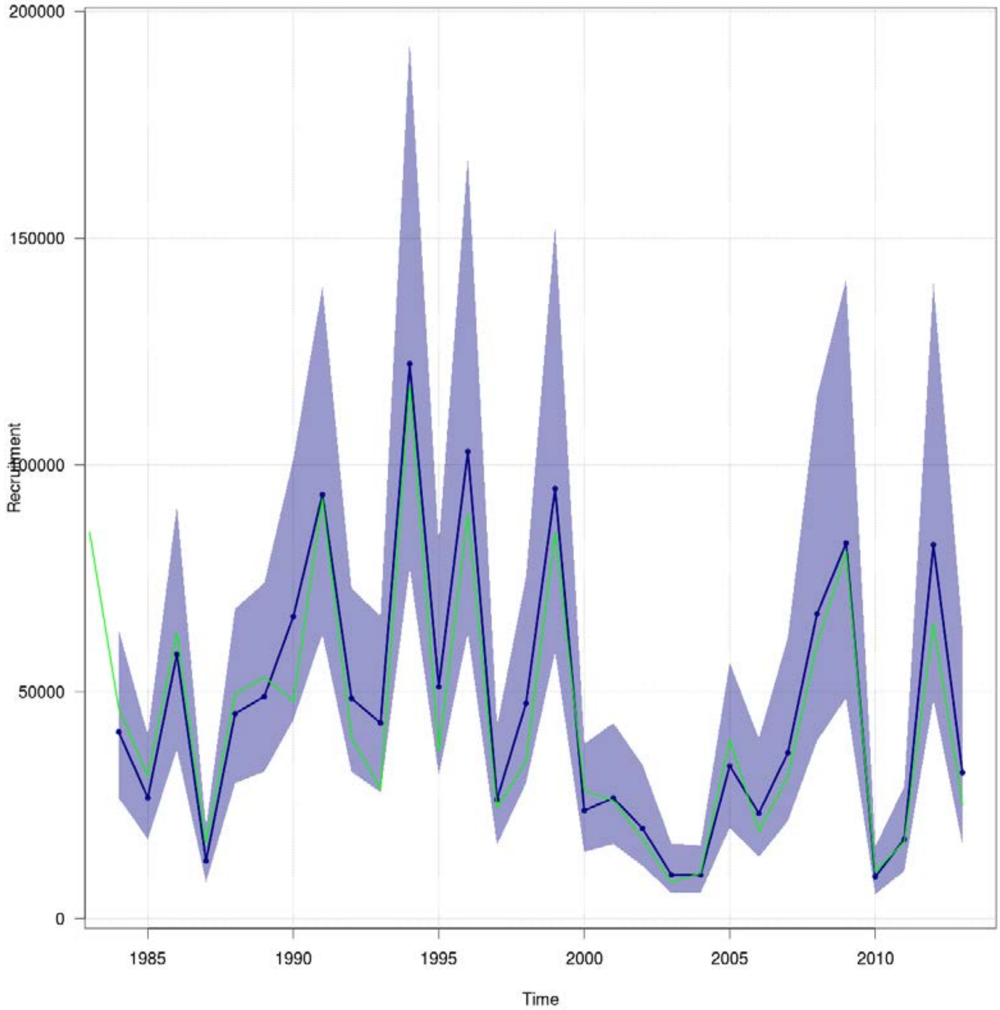

Figure 3.6.5.3. Estimated recruitment. Blue is SESAM, green is SXSA.

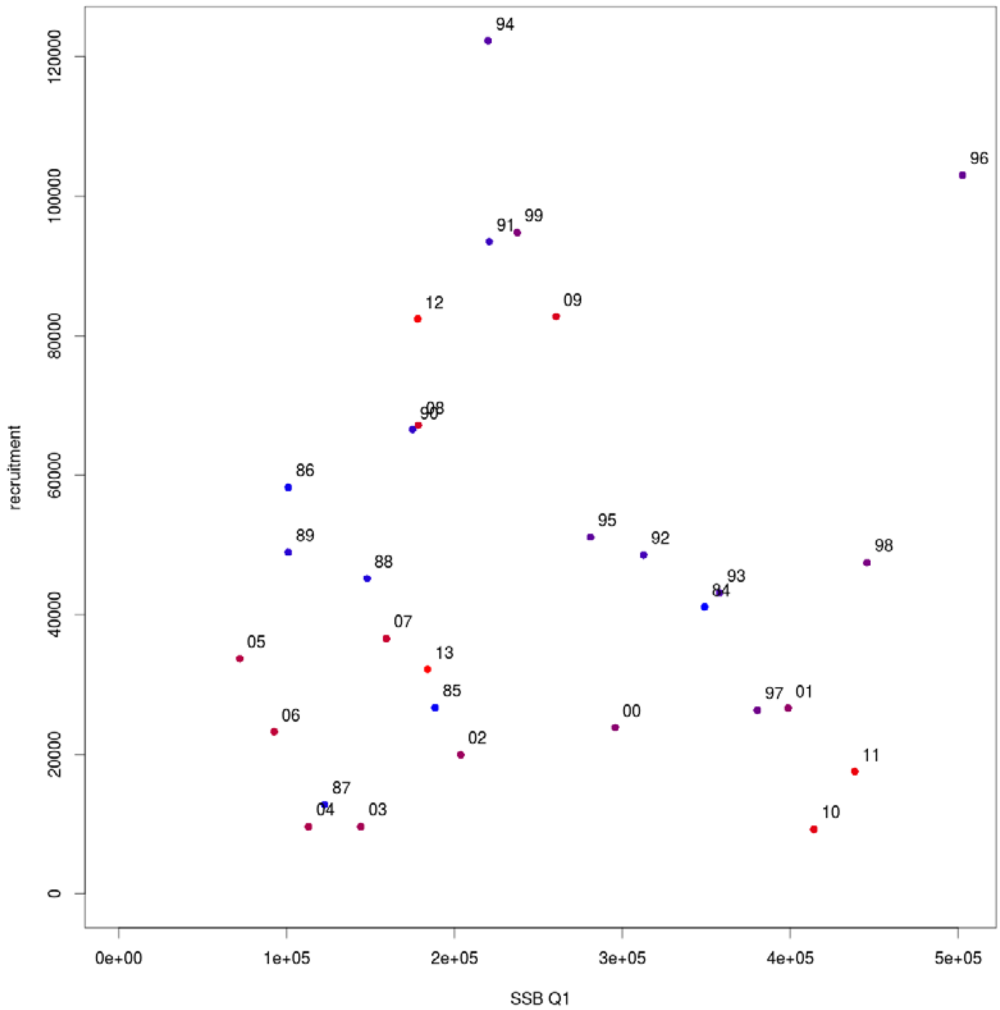

Figure 3.6.5.4. Stock–recruitment from SESAM. SSB in quarter 1. The corresponding plot with SSB in quarter 4 is similar. Colours are associated with the year (blue for earliest to red for most recent).

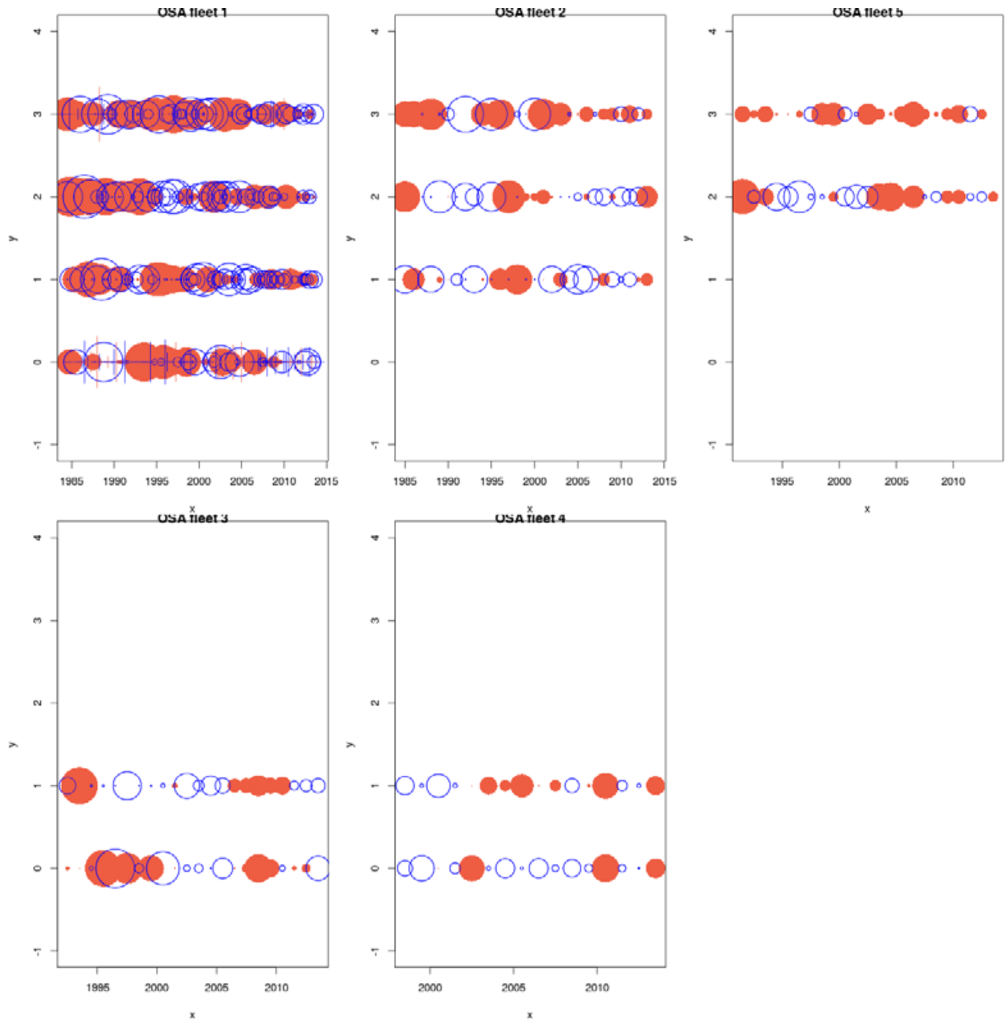

Figure 3.6.5.5. One step ahead residuals from SESAM by fleet.

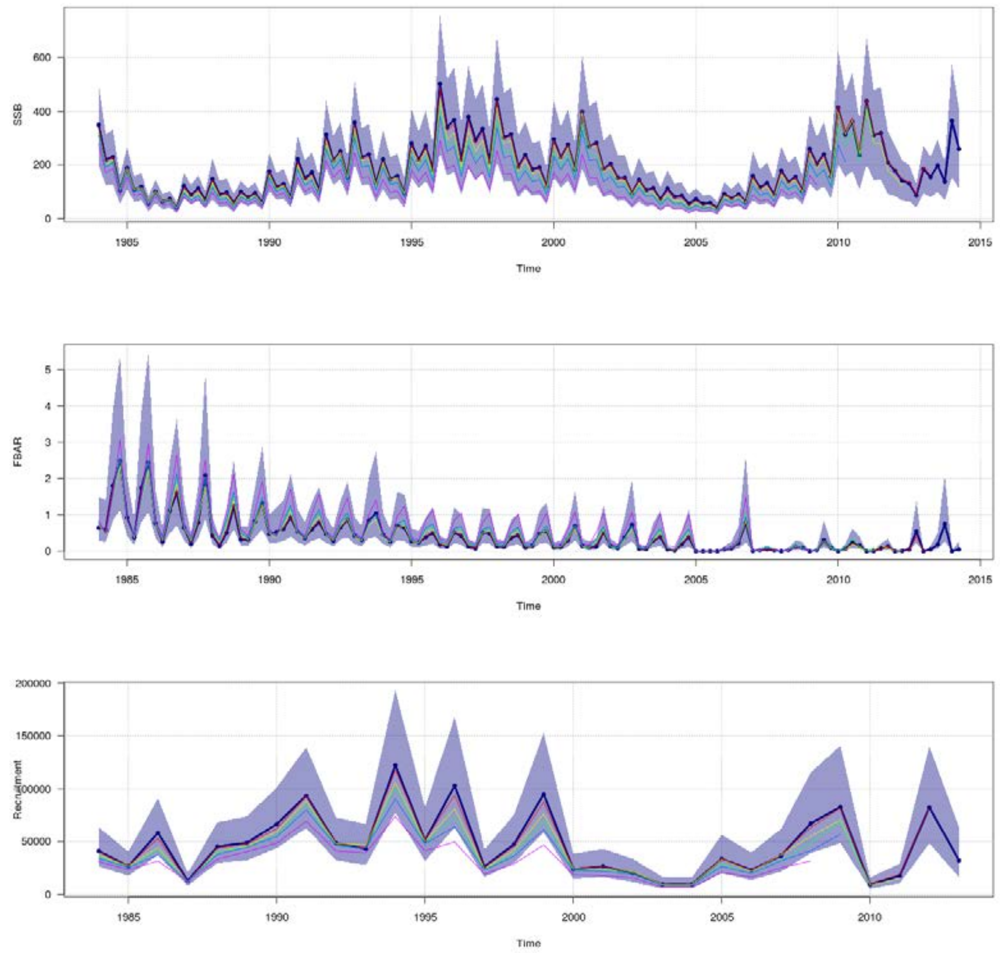

Figure 3.6.5.6. Retrospective diagnostic for SESAM.

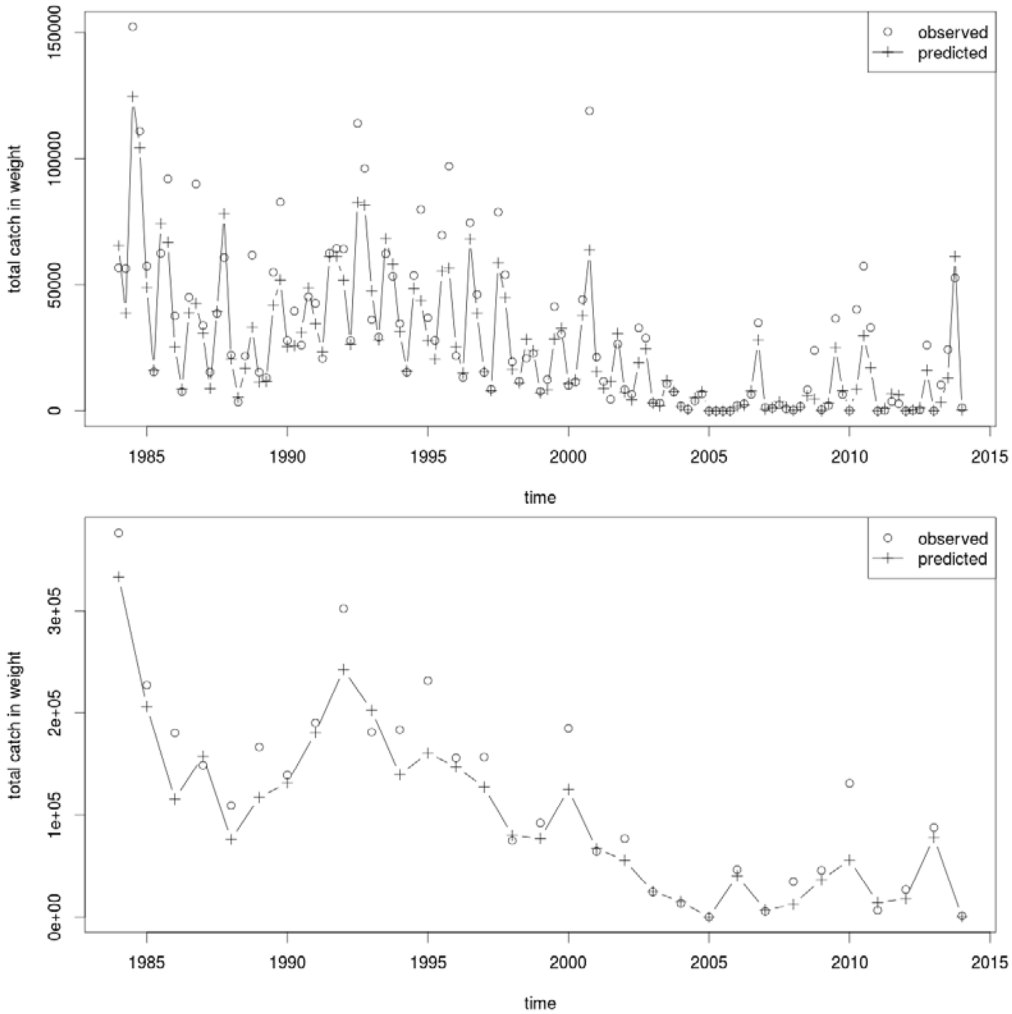

Figure 3.6.5.7. Total catch weight observed vs. predicted by quarter (top) and year (bottom).

Table 3.6.5.1. The minimum of the estimated SSB time-series by quarter.

SSB	Quarter	Year
72101.23	1	2005
55109.70	2	2005
57961.80	3	2005
39447.18	4	2005

Table 3.6.5.2. Estimated recruitment, spawning–stock biomass (SSB), and average fishing mortality for ages 1 to 2 (F12). Note, F values are yearly means, and therefore the values for 2014 are not shown because this year is incomplete.

Time	Recruits	Low	High	SSB	Low	High	F12	Low	High
1984				348992	198372	499611	1.382	0.918	2.079
1984.25				218915	124966	312865			
1984.5	41144	26581	63685	229810	128306	331314			
1984.75				105632	53912	157352			
1985				188435	110185	266685	1.374	0.883	2.139
1985.25				109063	61709	156417			
1985.5	26675	17588	40458	119137	67429	170846			
1985.75				55560	26841	84279			
1986				101005	57502	144507	0.936	0.573	1.527
1986.25				62992	34496	91488			
1986.5	58290	37337	91001	72403	40595	104212			
1986.75				39645	19650	59641			
1987				122584	75034	170134	0.936	0.532	1.644
1987.25				88173	51406	124939			
1987.5	12747	8101	20057	113597	65634	161560			
1987.75				69938	37104	102773			
1988				147915	71632	224198	0.583	0.352	0.964
1988.25				91039	41679	140399			
1988.5	45207	29892	68370	97703	45320	150086			
1988.75				58000	24436	91564			
1989				100932	59721	142144	0.694	0.416	1.158
1989.25				79658	46155	113160			
1989.5	48951	32399	73959	95305	55773	134837			
1989.75				58537	32146	84928			
1990				175035	104497	245574	0.637	0.387	1.048
1990.25				118470	69255	167684			
1990.5	66575	43766	101271	129717	73370	186064			
1990.75				79614	41762	117466			
1991				220656	130571	310742	0.574	0.349	0.945
1991.25				150325	85811	214839			
1991.5	93518	62737	139400	172470	97152	247787			
1991.75				106765	56026	157503			
1992				312686	186387	438985	0.570	0.351	0.925
1992.25				215978	125705	306250			
1992.5	48558	32380	72821	251936	146275	357597			
1992.75				154021	83605	224438			
1993				357862	202997	512727	0.655	0.363	1.184
1993.25				229863	124280	335446			
1993.5	43151	27901	66735	240384	127682	353086			
1993.75				133350	59979	206721			
1994				219996	109786	330206	0.519	0.293	0.919
1994.25				148390	68250	228530			

Time	Recruits	Low	High	SSB	Low	High	F12	Low	High
1994.5	122325	77384	193366	158702	74518	242886			
1994.75				94072	38371	149772			
1995				281013	151769	410258	0.349	0.192	0.634
1995.25				218606	114379	322833			
1995.5	51114	31730	82341	271795	140893	402697			
1995.75				180756	88183	273329			
1996				502611	246336	758886	0.312	0.168	0.580
1996.25				340110	161029	519191			
1996.5	103014	63180	167962	368834	172770	564898			
1996.75				219710	88839	350580			
1997				380415	188170	572661	0.305	0.162	0.574
1997.25				292755	142257	443252			
1997.5	26311	16316	42429	335067	168445	501689			
1997.75				211021	96873	325169			
1998				445703	209556	681849	0.267	0.144	0.493
1998.25				303260	138036	468484			
1998.5	47477	29893	75406	314371	140845	487898			
1998.75				193030	77565	308494			
1999				237289	112190	362388	0.321	0.170	0.605
1999.25				183342	85223	281460			
1999.5	94836	58847	152834	190559	91456	289661			
1999.75				119615	52964	186267			
2000				295683	152522	438843	0.306	0.159	0.588
2000.25				228771	117182	340360			
2000.5	23818	14724	38530	275652	141783	409522			
2000.75				182925	89044	276805			
2001				398720	185848	611593	0.229	0.117	0.450
2001.25				269432	120551	418313			
2001.5	26614	16435	43098	282329	124625	440032			
2001.75				185154	78637	291670			
2002				203672	91403	315941	0.335	0.158	0.709
2002.25				152314	65580	239047			
2002.5	19946	11710	33977	152271	68182	236361			
2002.75				95599	39329	151869			
2003				144204	61904	226504	0.202	0.091	0.447
2003.25				105988	44806	167169			
2003.5	9649	5627	16543	114006	49409	178604			
2003.75				72883	28630	117137			
2004				113008	46822	179193	0.161	0.068	0.380
2004.25				82125	33389	130862			
2004.5	9616	5738	16113	85721	35797	135645			
2004.75				55438	21622	89254			
2005				72101	30166	114036	0.000	0.000	0.001
2005.25				55110	23285	86934			
2005.5	33690	20098	56474	57962	25768	90155			

Time	Recruits	Low	High	SSB	Low	High	F12	Low	High
2005.75				39447	17736	61158			
2006				92574	48641	136507	0.285	0.111	0.733
2006.25				74969	39087	110851			
2006.5	23229	13589	39707	91470	46988	135953			
2006.75				62375	30605	94146			
2007				159445	67777	251113	0.030	0.015	0.063
2007.25				116563	50368	182757			
2007.5	36598	21586	62049	132963	58296	207629			
2007.75				90811	39362	142261			
2008				178479	87550	269407	0.063	0.031	0.128
2008.25				137876	68118	207634			
2008.5	67194	39186	115220	155036	77108	232965			
2008.75				104769	50784	158753			
2009				260569	131341	389797	0.108	0.048	0.246
2009.25				202838	103059	302617			
2009.5	82785	48640	140899	240532	122024	359040			
2009.75				157658	74263	241053			
2010				414051	203174	624929	0.118	0.056	0.250
2010.25				313605	155391	471819			
2010.5	9245	5378	15893	360294	177270	543319			
2010.75				236288	109206	363370			
2011				438426	201293	675559	0.055	0.025	0.120
2011.25				310881	143122	478640			
2011.5	17517	10523	29157	318424	146342	490505			
2011.75				208080	92904	323256			
2012				178035	83755	272314	0.151	0.064	0.356
2012.25				141694	66769	216620			
2012.5	82408	48438	140199	131318	64059	198577			
2012.75				86189	42109	130269			
2013				183982	95056	272909	0.247	0.103	0.594
2013.25				155141	80095	230186			
2013.5	32187	16305	63540	197688	100381	294995			
2013.75				137518	67510	207525			
2014				364881	154561	575201			
2014.25				259887	111916	407858			

3.7 Short-term projections

The short-term forecast is stochastic, which allows the probability of SSB being below B_{lim} to be evaluated immediately following the fishing season. The SESAM is, like the SXSA, a quarterly based model estimating biomass at the start of each quarter of the year. As explained under Section 3.8 the benchmark has decided that the $B_{lim} = B_{loss}$ should be the lowest SSB estimated in quarter 4, because this is closest to the beginning of the fishing season (1st November), and would be the most appropriate to use as a B_{lim} reference point, because the probability of SSB being below B_{lim} can then be evaluated immediately after the fishing season for which a TAC is being calculated. It was argued that the quarter 4 SSB (an existing output of the SESAM model) was adequate for this purpose because any attempt to calculate an SSB corresponding to 1st November would require further assumptions and would effectively only be an interpolation between the quarter 4 and subsequent quarter 1 SSBs, thus unnecessarily complicating the calculation of the SSB. The forecast provides a TAC advice according to a calculated yield in the forecast year where the probability of SSB being below B_{lim} by 1st October in the forecast year is less than 5%, i.e. the forecast estimates the yield according to SSB that meets the 5% criterion at the B_{lim} date which is 1st October as explained above. Accordingly, it is recommended that this TAC is used for the management year 1st November–31st October. This is an approximation and will be sustainable unless radical changes occur in the seasonal fishing pattern used in the forecast. In the period between 1st October and 1st November in the forecast year there will be provided a new assessment.

Short-term projections are carried out as follows.

1) Assume values for M, weight-at-age in the catches and in the stock, and maturity-at-age for the projection period. Since all of those quantities except weight-at-age in the catches are assumed constant over time, only weight-at-age requires special treatment. A procedure for forecasting catch weights is described in WD6 (Annex 3), but see also below.

2) Draw K samples from the joint posterior distribution of the states (log N and log F) in the last year with data, and the recruitment in all years.

3) Assume that log F_t = log F_{t-4} + log G_t, for all future values of t where G_t is some chosen vector of multipliers of the F-process. If $G_t = 1$ for all t this corresponds to assuming the same level and quarterly pattern in F for all future time-steps as in the last data year.

4) Create K forecasting trajectories starting from the samples of joint posterior distribution of the states. The is done by sampling K recruitments from the vector of historic recruitments obtained in step 2, and then projecting the states forward in time using the stock equation with randomly sampled process errors from their estimated distribution.

5) Find G_t such that the fifth (or any other) percentile of the catches (total mass) in the projections equal some desired level such as B_{lim} (optional).

Forecasting weight-at-age in the catches

There is substantial variation in weight-at-age in the commercial catches from year to year, which means that usual methods of using running averages will be quite sensitive to the bandwidth of the running average. This is important, since TAC estimates calculated in step 5 above depend directly on the catch weight-at-age.

The following models is used:

$$E(\sqrt{CW_{a,q,t}}) = \mu_{a,q} + s(cohort, a) + U_t$$

where $\mu_{a,q}$ is a mean for each combination of quarter and age, *s*( ) is tensor product smoothing spline, and U_t are normal distributed random effects. There square root transform is used to achieve variance homogeneity in the residuals. See Figure 1 in WD6 (Annex 3).

Example forecast

The assessment developed during the benchmark was based on the same data as used in the May 2014 assessment (see Section 3.6.5), so the forecast example is consistent with this. The example itself is therefore not how it will actually appear in a September assessment (it is shifted to a different period), but is given to demonstrate how the forecast will actually look (albeit for a different period).

Table 3.7.1 illustrates a forecast that would be associated with a May 2014 assessment, where the B_{lim} is the B_{loss} estimated in quarter 2 (B_{lim}=B_{loss} in quarter 2=55.110 thousand tonnes; see Table 3.6.5.1), for the 5% B_{lim} forecast option. The catch forecast for a May assessment and forecast would then simply be summing up the catches for quarters 2014.25 (Q2, 2014), 2014.5 (Q3, 2014), 2014.75 (Q4, 2014) and 2015 (Q5, 2015). Tables 3.7.2 and 3.7.3 provide corresponding forecasts for zero F and a *status quo* F options.

A September forecast would be similar, but with B_{lim} consistent with a B_{loss} estimated in quarter 4 (B_{lim}=B_{loss} in quarter 4=39.447 thousand tonnes) and catches summed for consecutive quarters 4, 1, 2 and 3, starting in the year the assessment is conducted.

Table 3.7.1. Forecast with F scaled such that the fifth percentile of the SSB distribution one year ahead equals B_{lim}. SSB is in the unit of thousands of tonnes, however catches are tonnes.

	F12	SSB	SSB 5TH QUANTILE	MEDIAN CATCH
2014.25	0.16	260.19	162.84	42 188.57
2014.5	0.59	272.22	160.85	115 141.67
2014.75	2.46	153.18	81.47	204 881.51
2015	0.01	151.75	68.02	1483.05
2015.25		121.36	55.11	
Sum				363 694.80

Table 3.7.2. Forecast with zero F.

	F12	SSB	SSB 5TH QUANTILE	MEDIAN CATCH
2014.25	0.00	260.19	162.84	0.00
2014.5	0.00	292.04	185.00	0.00
2014.75	0.00	200.82	127.20	0.00
2015	0.00	279.34	179.11	0.00
2015.25		215.88	137.41	
Sum				0.00

Table 3.7.3. Forecast with *status quo* F.

	F12	SSB	SSB 5TH QUANTILE	MEDIAN CATCH
2014.25	0.05	260.19	162.84	14 067.58
2014.5	0.19	285.38	177.84	44 996.32
2014.75	0.77	183.20	110.78	115 300.17
2015	0.00	226.71	130.00	722.54
2015.25		177.80	101.60	
Sum				175 086.61

3.8 Appropriate reference points (MSY)

ICES MSY approach for short-lived species deviates from a standard ICES F_{MSY} approached. The reason is that the SSB for short-lived species is largely determined by incoming recruitment and that the natural mortality is high. So instead of selecting a fishing mortality that producers the highest long-term yield, the strategy is to allow for exploitation such that the stock is annually fished down to a certain level. This level is the SSB where probability of being above B_{lim} is high (95%). Since the SESAM model delivers a stochastic forecast, it is possible to predict the TAC that will result in a forecasted SSB being above B_{lim} with 95% certainty. Thus, only relevant reference point to decide on is B_{lim}, as F_{pa} and F_{lim} are not applicable to short-lived stocks.

Based upon stock–recruitment plots, the group found that the stock–recruitment plot of Norway pout equalled a type 5 Stock–recruitment (ICES, 2016). A type 5 stock is defined as "*Stocks with no evidence that recruitment has been impaired or with no clear relation between stock and recruitment (no apparent S–R signal).*" This implies that B_{lim}=B_{loss}, and hence the new B_{lim} value will be set equal to B_{loss} taken from the 2016 benchmark run.

The benchmark decided that the B_{loss} should be the lowest SSB estimated in quarter 4, because this is closest to the beginning of the fishing season (1st November), and would be the most appropriate to use as a B_{lim} reference point, because the probability of SSB being below B_{lim} can then be evaluated immediately after the fishing season for which a TAC is being calculated. It was argued that the quarter 4 SSB (an existing output of the SESAM model) was adequate for this purpose because any attempt to calculate an SSB corresponding to 1st November would require further assumptions and would effectively only be an interpolation between the quarter 4 and subsequent quarter 1 SSBs, thus unnecessarily complicating the calculation of the SSB.

According to Table 3.6.5.1, B_{lim} = 39 447 t (B_{loss} value in quarter 4, 2005).

3.9 External Reviewers' comments

WKPOUT Benchmark Workshop: External Reviewers Report

Jerald S. Ault (Chair, USA), Daniel Hennan (USA), Verena Trenkel (France)

The External Review Panel met for a benchmark workshop on Norway Pout (WKPOUT 2015/2/ACOM36) at ICES Headquarters in Copenhagen on August 24–26, 2016, to discuss the new assessment analyses and results with regional stock assessment scientists and ICES staff. Following the Terms of Reference, the External Review Panel's thoughts on the meeting were as follows:

(a) Evaluate the appropriateness of the data to determine stock status

To the fullest extent possible, objectivity was cornerstone of our collective decisions concerning data quality, outliers, or simply bad data.

The commercial cpue index was excluded from the model evaluated during WKPOUT. The commercial index formed a subset of the commercial catch-at-age data matrix used elsewhere in the modelling, and thus these were deemed to be highly correlated. In addition, the commercial index was calculated using catches from a limited subset of the stock spatial domain (i.e. a small number of statistical rectangles) which may be misleading if there was a positive relationship between stock abundance and spatial distribution.

Initially, a problem appeared when industry data (commercial cpue index) was left in the analysis which strongly suggested an apparent change in stock productivity and resiliency to change. The issue appeared to be the data challenges raised above and how and if the data collected from industry were representative. It was opined that the survey mechanics of collecting data and catches prior to 1990 were questionable.

The commercial cpue was relatively poorly fit by SESAM, contributed redundant information and was considered relatively unreliable by WKPOUT, as an unknown proportion of the catch in the early part of the time-series was misclassified as Norway pout (though previous working groups attempted to correct total catches for this, but not necessarily catches used for creating the cpue index).

The random walk variance parameter associated with the estimation of fishing mortality was substantially increased during the period where there was no directed fishery (and basically no or little catch) for Norway pout (i.e. 2005–2008) could be fit well by the model and conformed to the reality of the situation. This resulted in a more precise overall SESAM fit.

There was discussion concerning truncation of the data time-series (i.e. eliminate years 1983, and perhaps 1984) because these observations appeared anomalously high and some of it is not based on real data. In 1983 for example, no sampling of weights-at-age took place so that estimated catches-at-age (numbers) were based on using the weight-at-age matrix which in the past was used for the stock but which is now obsolete. However, no consensus was reached here with the information presented, so their removal at this point would appear arbitrary and capricious.

There still seem to be some issues with mean growth (size-at-age and the derived weight-at-age) in how it affects model estimation. More work is required here, both in terms of the sampling accuracy and precision achieved under the current design and the most statistically rigorous way to impute values for years where these data are missing or in question.

By and large, the reviewers agreed that these were prudent and well-justified choices.

(b) Document the preferred method for evaluating stock status

The primary assessment model (SESAM) chosen was a newly developed seasonal version of the SAM (State–Space) model.

The analysis began with an evaluation of model configurations comparing seasonal XSA and SESAM (seasonal SAM, quarterly state–space model). An extensive set of comparative model runs showed that both models produced relatively similar yield time-series; although there was some difference between models at the early part of the time-series where data quality was most questionable. However, the SESAM generated the predicted series with an apparent lower variance. As a consequence, the SESAM model was unanimously to be "preferred" by the working group over the SXSA (seasonal XSA) model that had been used in previous Norway pout assessments.

The SESAM preference was due to several favourable model properties:

1) Model estimates fewer parameters (i.e. 20 vs. 100s) to achieve the same solution;

2) Its state–space methodology is favourable for time-series estimation;

3) Allows for direct estimation of parameter uncertainty;

4) Allows for the inclusion of noise in the input data (does not assume perfect knowledge of input processes such as catches);

5) Output smoothness is estimated, rather than a result of model assumptions;

6) Performance of model and tests of predictability (forecasting) are inherent in the model framework, rather than separate processes;

7) Model developers were an integral part of the assessment working team, and they were present and quite helpful during the entire meeting, rather than unavailable;

8) Model seems appropriate to providing advice to management and can be used to reconcile previous ICES advice.

(c) Re-examine MSY and PA reference points

No sufficiently finalized proposals on the MSY and PA reference points were available to the External Review Panel for discussion with the working group during the benchmark workshop.

(d) Evaluate the settings of the escapement strategy

No sufficiently finalized proposals on the settings of the escapement strategy were available to the External Review Panel for discussion with the working group during the benchmark workshop.

(e) Recommendations and general comments for improving future assessments

There were some particularly unique challenges that made the timely development of assessment products difficult during this benchmark assessment review, including: (a) use of a new, purpose built, state–space assessment model; and, (b) data quality issues that in many cases were tough to judge with the information presented. As a consequence, the review team suggests the following changes for future Norway pout assessment reviews:

1) A suite of diagnostic tools must be developed for the SESAM model as soon as possible. Because SESAM is a new model, few standard diagnostic tools for performance exist. The review team recommends developing some additional diagnostic tools such as: (i) a better format for displaying and interpreting standardized model residuals over time (the bubble plots that were shown to us were horizontally compressed and very difficult to read and interpret); (ii) performance statistics based on prediction skill (e.g. how well does the model predict when a datapoint is removed?); (iii) likelihood profiles (if there is tension in the model, where does it occur?); (iv) some depictions of any gradient problems that may exist; (v) summary tables with AIC/BIC values for models using the same data (i.e. documentation of all intermediate models tested before arriving at the final choice of parameter coupling); (vi) statistics for model goodness-of-fit; and, (vii) plots showing retrospective patterns (and patterns when earlier years are left out). NB: This is not an exhaustive list *per se*.

2) The external review team would have liked to have seen more of the exploratory modelling work completed prior to the meeting, so that any challenges in achieving convergence, or other issues, would have been diagnosed and understood well before the meeting, and these issues could have been explained succinctly to the reviewers. For example, a thorough retrospective analysis with SESAM and tests of forecasting skills are required. This would

likely involve walking backward in time with the methodology and projecting results forward and comparing with data to determine model efficacy in a sequential manner.

3) Although the review team was relatively comfortable with the outcome of the assessment and agree that the terms of reference were met, some topics could have been addressed more fully and potentially buttressed with more substantive analyses. These included the listing of data input quality (what values are actual sampled data, what has been “borrowed”, etc.), choice(s) of reference points, the potential inclusion of the Norway shrimp survey that covers a relatively poorly sampled component of the population, and recommendations for additional information that might be provided by industry.

4) Additional sensitivity runs should probably be included in the next assessment, in particular the assumptions of time invariant growth, maturity and natural mortality may need to be considered. For the short term, projections that include different ways to handle mean weight-at-age, including projecting forward with specified uncertainty, should be more fully explored (smoothed historic time-series, average over some recent time period, etc.).

5) The SESAM model appears to be very flexible, but currently estimating relatively few parameters. The Norway pout assessment exhibits coherent indices and generally behaves well. The reviewers were left with the impression that some additional parameters might be estimable. We suggest that the assessment working group spend some time considering what might be worth investigating in future assessments. For example, a clear linkage between states of maturity and natural mortality.

6) There are currently two recruit indices (age 0) being used in model parameter estimation. To avoid duplicative information being introduced into the assessment, a method should be developed that combines the Scottish and the English indices into a single robust index. In general, there were a number of problems and questions regarding error variances of the data that were not ultimately addressed that had to do with sampling mechanics, sampling theoretics and sampling designs for both fishery-independent data, and for those obtained from the fleets. It would make sense to conduct a thorough design analyses of these data at the earliest possible time, and to ensure that re-analyses are performed after every data collection period so that precision is maximized for use in assessment modelling.

Final comment

We believe that benchmark review of this stock could have been substantially more efficient. In general, the review team felt that too much time was spent on discussion on a number of relatively straight-forward decisions that could have been made prior to the benchmark meeting. In a number of instances, this left little time for the discussion of other substantially more important topics.

The stock assessment working group must produce the various working documents much further ahead of the review meeting. As it was, some working documents were only available and added to the website less than 24 hours before the start of the meeting, which deleteriously affected a comprehensive and objective review process. We believe that reviewers must have sufficient time to read and assimilate the contents of the documents prior to the meeting so that the productivity of the group is maximized and outcomes are clear and on-target!

4 Conclusions

The benchmark supports the move from SXSA to SESAM

Among the advantages of SESAM over SXSA is its ability to incorporate process and observation error, including relaxing the assumption that catches are exact, and its ability to estimate uncertainties in all quantities, including the forecast, a feature lacking in SXSA. Propagating assessment uncertainty into the forecast allows an evaluation of the probability of SSB falling below B_{lim} immediately following the fishing season, an important feature of SESAM.

The benchmark supports the omission of the early commercial cpue data from the SESAM assessment

The principle reason for this is that the commercial cpue dataseries is not independent of the catches, because there is substantial overlap between the two dataseries. This is problematic because the model assumes such independence, and if used, these data will have greater weight in the model fit relative to other data sources as a result, potentially biasing the assessment. Independent survey data are available for the same period, so the model does not rely on the commercial cpue data and performs well without them, with observed trends with and without these data being similar.

The benchmark supports the omission of 1983 from the assessment

This is because there was concern regarding missing observations of weight-at-age in the catch for 1983, which casts doubt on the accuracy of the numbers-at-age in the catch for that year. However, support for the omission was not unanimous, and had to go to a vote (see Section 3.9: Reviewers' comments).

The benchmark supports the use of the SSB at the start of quarter 4 as the basis for deriving B_{lim}

It was felt that the reference point had to align with the start of the fishing season (1st November to 31 October), and the closest match to this as an output from the model was the SSB at the start of quarter 4 (1st October); any attempt to calculate a B_{lim} aligned exactly with the start of the fishing season would require interpolation and further assumptions, and it was felt that the quarter 4 SSB was adequate and avoided these further assumptions.

The benchmark did not have access to the model estimates needed to derive B_{lim}, so discussed the principles for its derivation only (see Section 3.8); there was also insufficient time to discuss the forecast in detail, although an example forecast is provided (see Section 3.7). See Section 3.9 (reviewers' comments) for further feedback and comments on the benchmark.

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Annex 2: Agenda

WKPOUT: Copenhagen, 23–25 August 2016

Tuesday: 9am start

Morning

1) Introduction and ToRs
2) WD2: Danish Norway pout fishery in the North Sea and Skagerrak
3) WD3: Norwegian industrial fishery for Norway pout in the North Sea
4) WD1 (Subsections 1–5): Norway pout population dynamics and ecological role in the North Sea and Skagerrak
5) WD6: SESAM applied to Norway pout in the North Sea
6) Assessment

Afternoon

7) Assessment (contd.)

Wednesday: 9am start

Morning

8) WD4: Check of age readings of Norway pout in the North Sea between Denmark and Norway
9) WD5: Estimation of abundance of Norway pout from shrimp surveys using StoX
10) Assessment (contd.)

Afternoon

11) Assessment (contd.)
12) WD1 (Subsections 6–7): Norway pout population dynamics and ecological role in the North Sea and Skagerrak

Thursday: 9am start

Morning

13) Reference points and forecast
14) Report writing

Afternoon

15) Report writing and wrap-up (16:30 latest)

Annex 3: Working documents

The following working documents were presented to WKPout 2016 and are included in full in Annex 3:

WD1: Norway Pout Population Dynamics and Ecological Role in the North Sea and Skagerrak. J. Rasmus Nielsen.

WD2: Danish Norway Pout Fishery in the North Sea and Skagerrak. J. Rasmus Nielsen, Jeppe Olsen, Kirsten Birch Håkonsson, Josefine Egekvist and Jørgen Dalskov.

WD3: Norwegian Industrial Fishery for Norway Pout in the North Sea. Espen Johnsen, Robert Misund, Snorri Runar Palmason and Geir Blom.

WD4: Check of Age Readings of Norway Pout in the North Sea between Denmark and Norway. Julie Olivia Davies, J. Rasmus Nielsen and Lotte Worsøe Clausen.

WD5: Estimation of Abundance of Norway Pout from Shrimp Surveys using the New Open Source of Software StoX. Espen Johnsen and Guldborg Søvik.

WD6: SESAM- Seasonal State–space Assessment Model Applied to Norway Pout in the North Sea. Anders Nielsen and Casper W. Berg.

Working Document ICES CM 2016/xx WKPOUT

Norway pout population dynamics and ecological role in the North Sea and Skagerrak

J. Rasmus Nielsen, DTU Aqua

1. Introduction

This working document presents Norway pout population dynamics and the ecological role of the Norway pout stock in the North Sea and Skagerrak (ICES Area IV and IIIa), nop34, relevant for the ICES benchmark assessment for the stock in August 2016, ICES WKPOUT.

The working document is subdivided into 7 main sections with different ecosystem aspects and considerations.

1. Introduction
2. Stock distribution and density patterns
3. Maturity, spawning, spawning distribution and migration
4. Stock delineation and definition
5. Mortality life history aspects (in relation to growth and maturity)
6. Multi-species information and considerations in relation to its ecological role
7. Environmental drivers
8. Annexes A.1 and A.2

2. Stock Distribution and Density patterns

Stock distribution and density patterns

Norway pout is distributed from the west of Ireland to Kattegat, at the Faroe Islands, and from the North Sea to the Barents Sea. The distribution for this stock is in the northern North Sea (>57°N) and in Skagerrak at depths between 50 and 250 m (Raitt 1968; Sparholt *et al.* 2002b; Lambert *et al.* 2009).

The Norway pout distribution and density patterns by age group in different periods over a 30 year period up to 2016 in the North Sea and Skagerrak-Kattegat (ICES Divisions IV and IIIa) are shown in **Figures 1-2.** More detailed figures of yearly distribution patterns are shown in **Appendix A.1** and **A.2** to the present working document. The figures show geographical distribution and density patterns of Norway pout as the catch per unit of effort (CPUE in number of fish per hour) by age and for all age groups combined in the ICES International Bottom Trawl Surveys (ICES IBTS) in 1st and 3rd quarter of the year for a 30 year period from 1985 to 2016. The data originates from downloads/extracts from the ICES DATRAS database in August 2016. The IBTS Surveys only cover areas within the 200 m depth zone. However, very few Norway pout are caught at depths greater than 200 m in the North Sea and Skagerrak on shrimp trawl survey (Sparholt *et al*. 2002b). For the Norwegian Trench, Albert (1994) found Norway pout at depths greater than 200 m, but very few deeper than 300 m.

The distribution in **Figure 1** and **Appendix A.1** is as observed in the Quarter 1 North Sea IBTS surveys by longer period or year, (quarter), and ICES rectangle for the period 1985-2016 for age groups of

Norway pout. The distribution of stock density patterns are shown on the maps as survey catch per unit of effort (CPUE), i.e. catch rates in number of individuals per trawl hour (no of fish caught). The data used for the calculations are CPUE per age group per survey trawl haul as extracted and downloaded from the ICES DATRAS database. The mean CPUE as number per trawl hour per age group (or summed over age groups) by survey (i.e. by year and quarter) is calculated for each ICES rectangle as the mean number per hour of all hauls performed in each rectangle. The mean CPUE per rectangle are either calculated as averages per year (**Appendix A.1**) or as averages over several years, i.e. in longer periods (**Figure 1**). The same is shown in **Figure 2** and **Appendix A.2** but for the 3rd quarter in the Quarter 3 IBTS survey for the period 1991-2015 and also including the age group 0 which is observed representatively in the third quarter IBTS survey as well.

The IBTS mean CPUE (numbers per hour) by quarter as an average for the full period 1991-2004 is shown in **Figure 3** where the boundary between the EU and the Norwegian EEZ are included on the map as well.

Finally, the positions fished at the International Bottom Trawl Survey (IBTS) first quarter and the mean CPUE (numbers) of Norway pout by rectangle for the full period 1981–1999 is shown in **Figure 4**. The standard area used to calculate abundance indices and the 200 m depth contour is also shown.

In general, highest densities of Norway pout of all age groups are found in the northern North Sea. Densities by year varies according to strong cohorts in the stock. The strong cohorts observed in the period are the 1986, 1989, 1991, 1994, 1996, 1999, 2008, 2009, 2012, and 2014 year classes. There seems to be a tendency towards the young fish density has decreased in the later period compared to the previous period before and after year 2000.

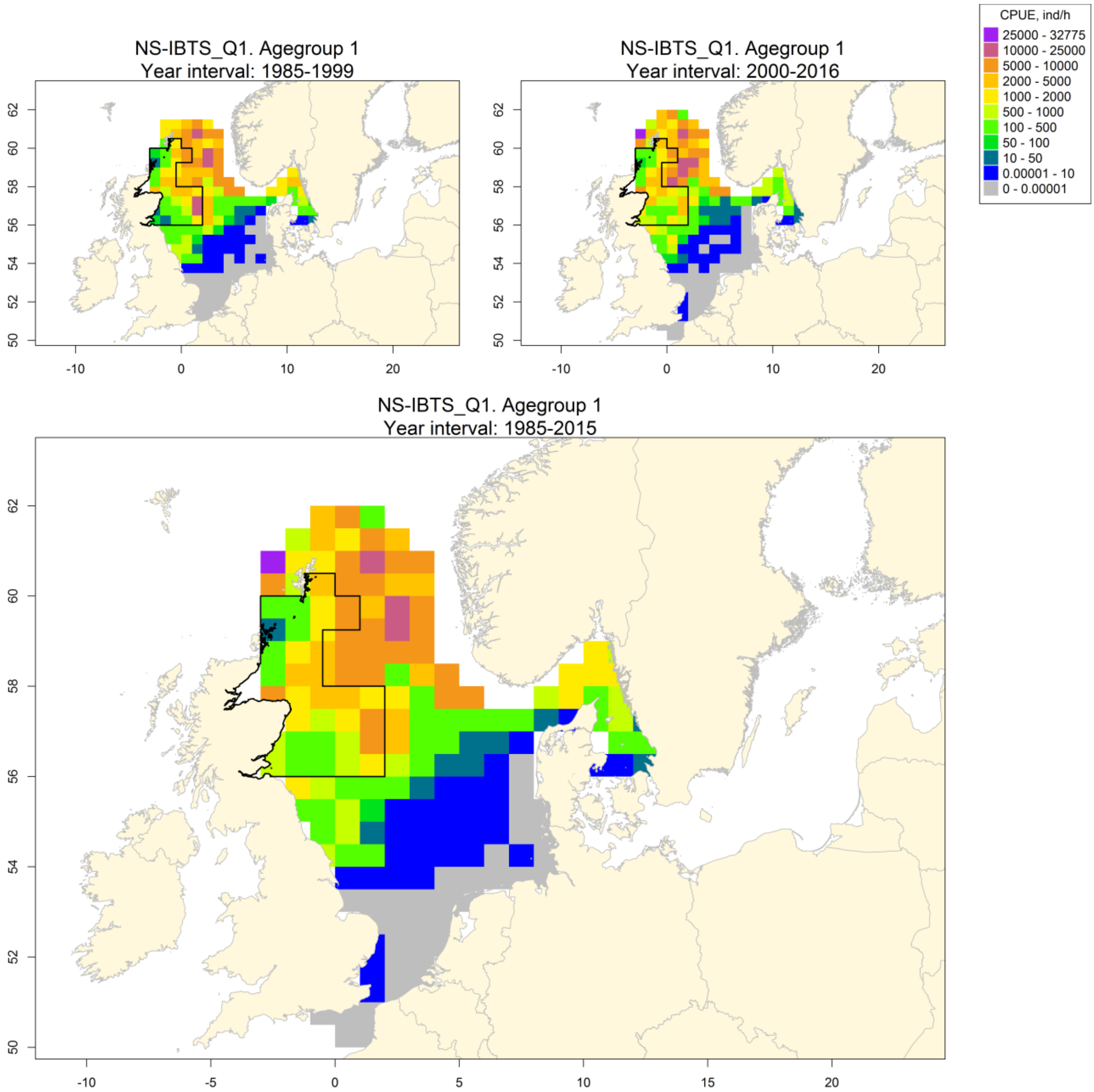


Figure 1. Catch per unit of effort (No/h) of Norway pout by age, ICES rectangle, (quarter) and time period for the IBTS Quarter 1 survey (IBTS Q1) in the period 1985-2016. Furthermore, the difference in CPUE per time period is shown in the figure on the next page. The "Norway pout box" is shown on the maps.

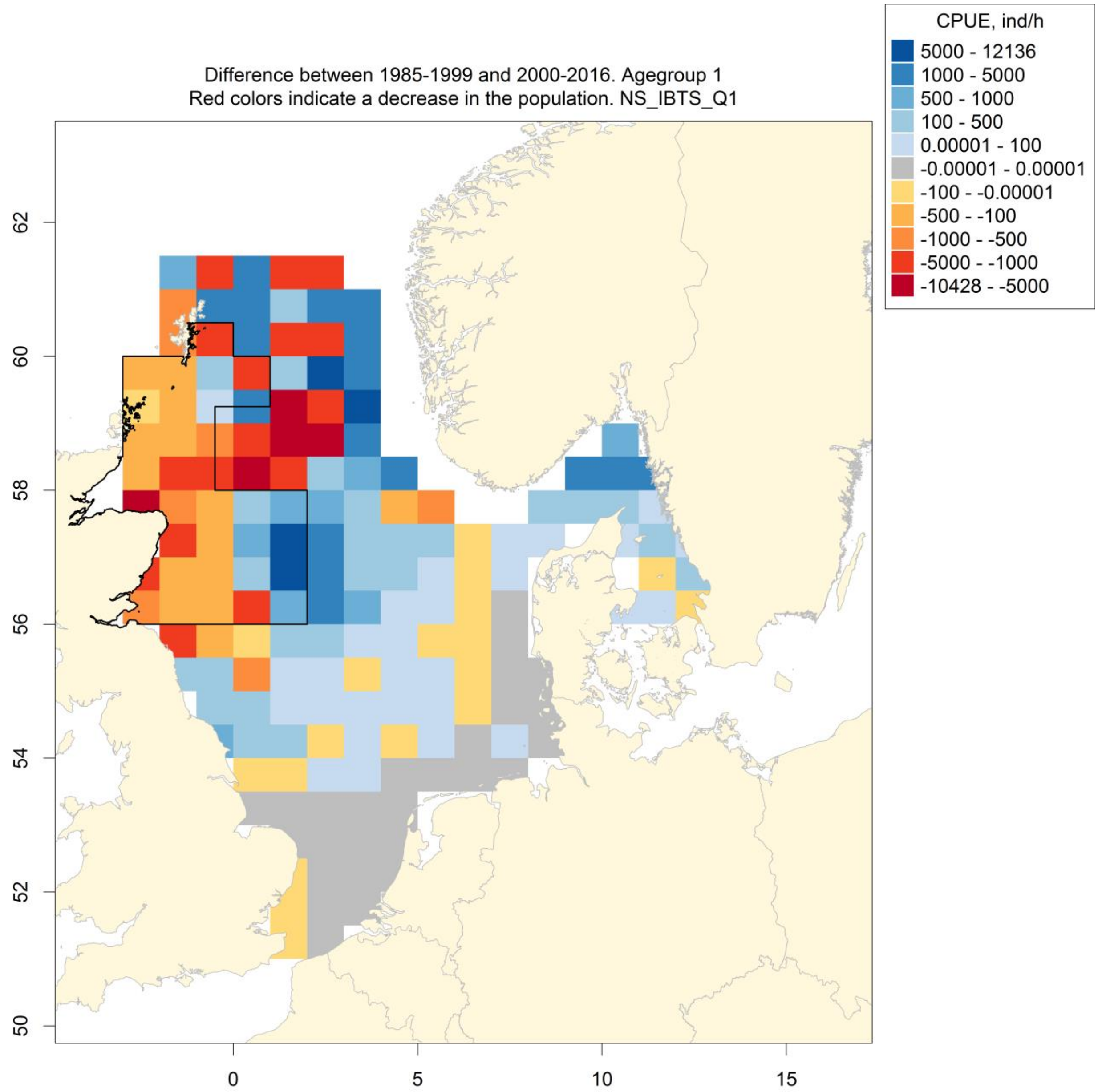
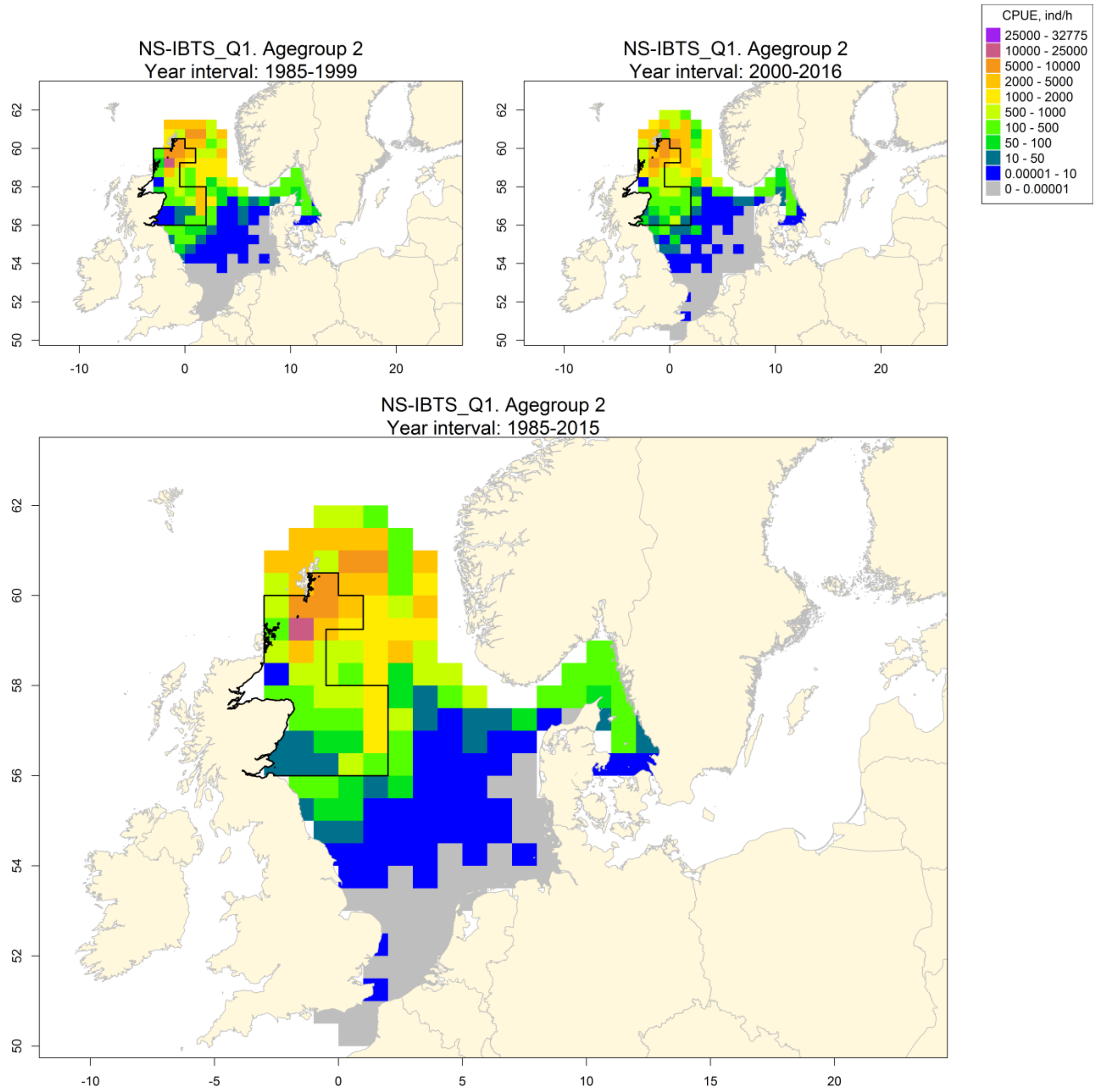


Figure 1. (Continued).



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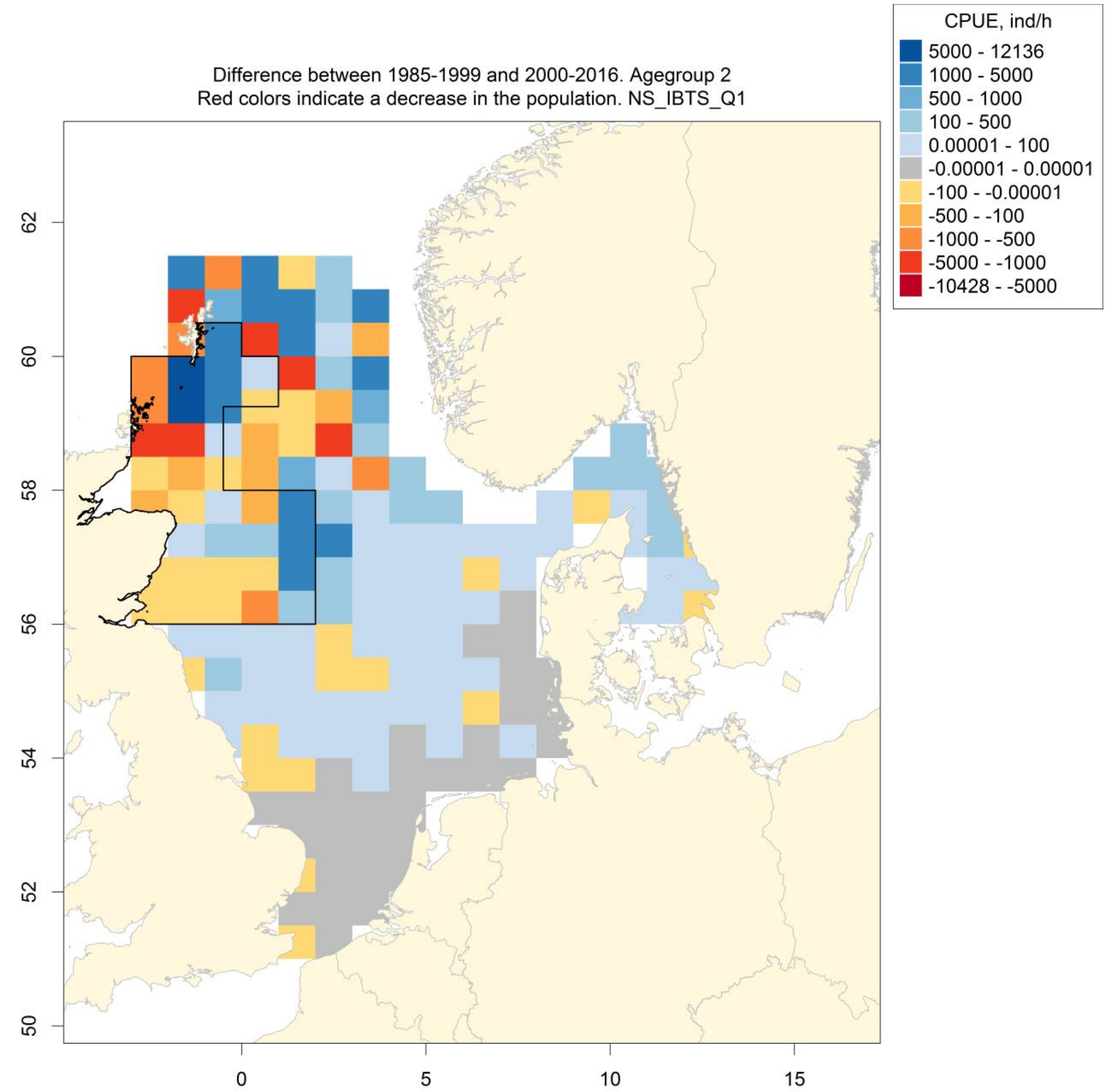

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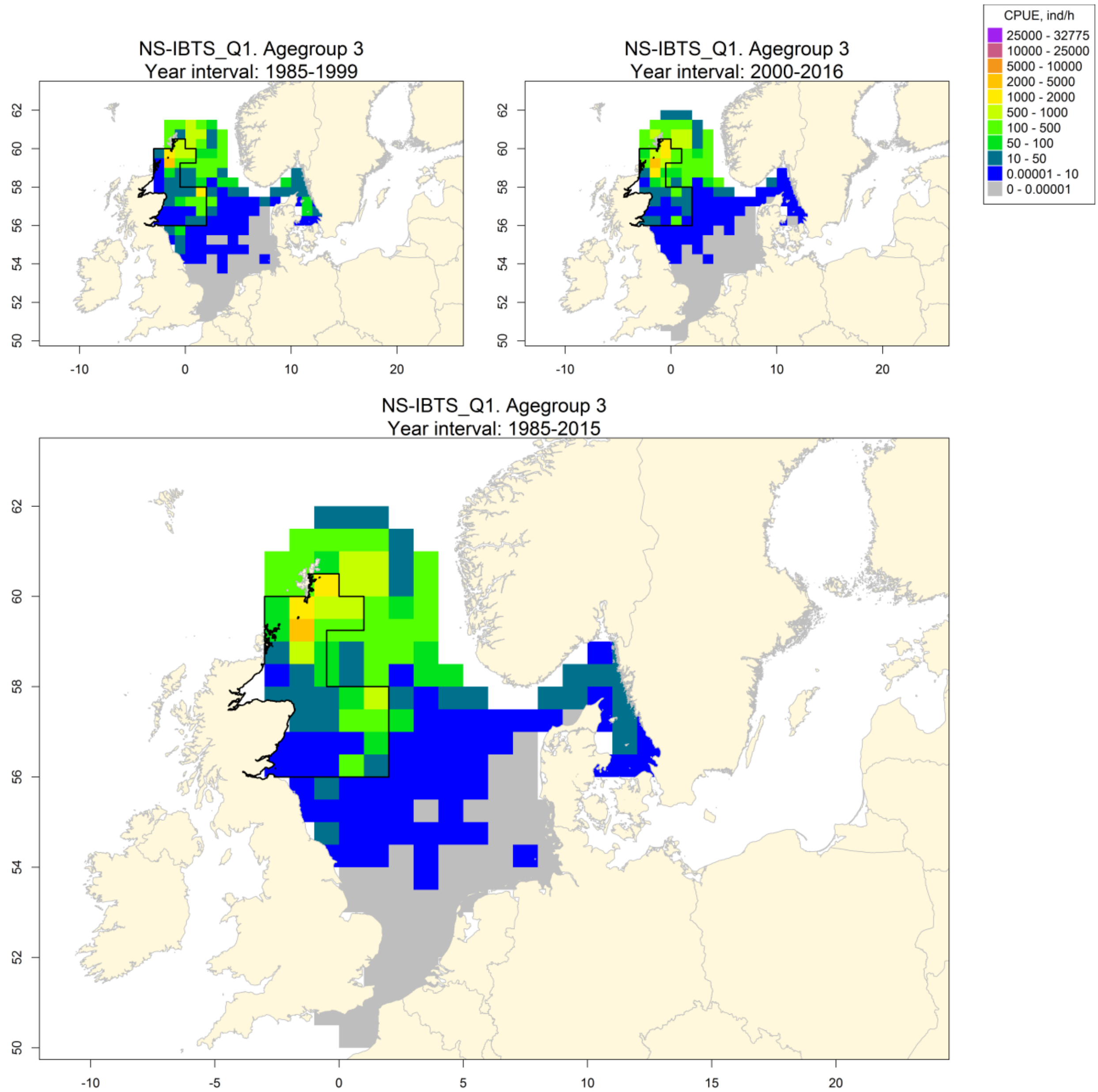
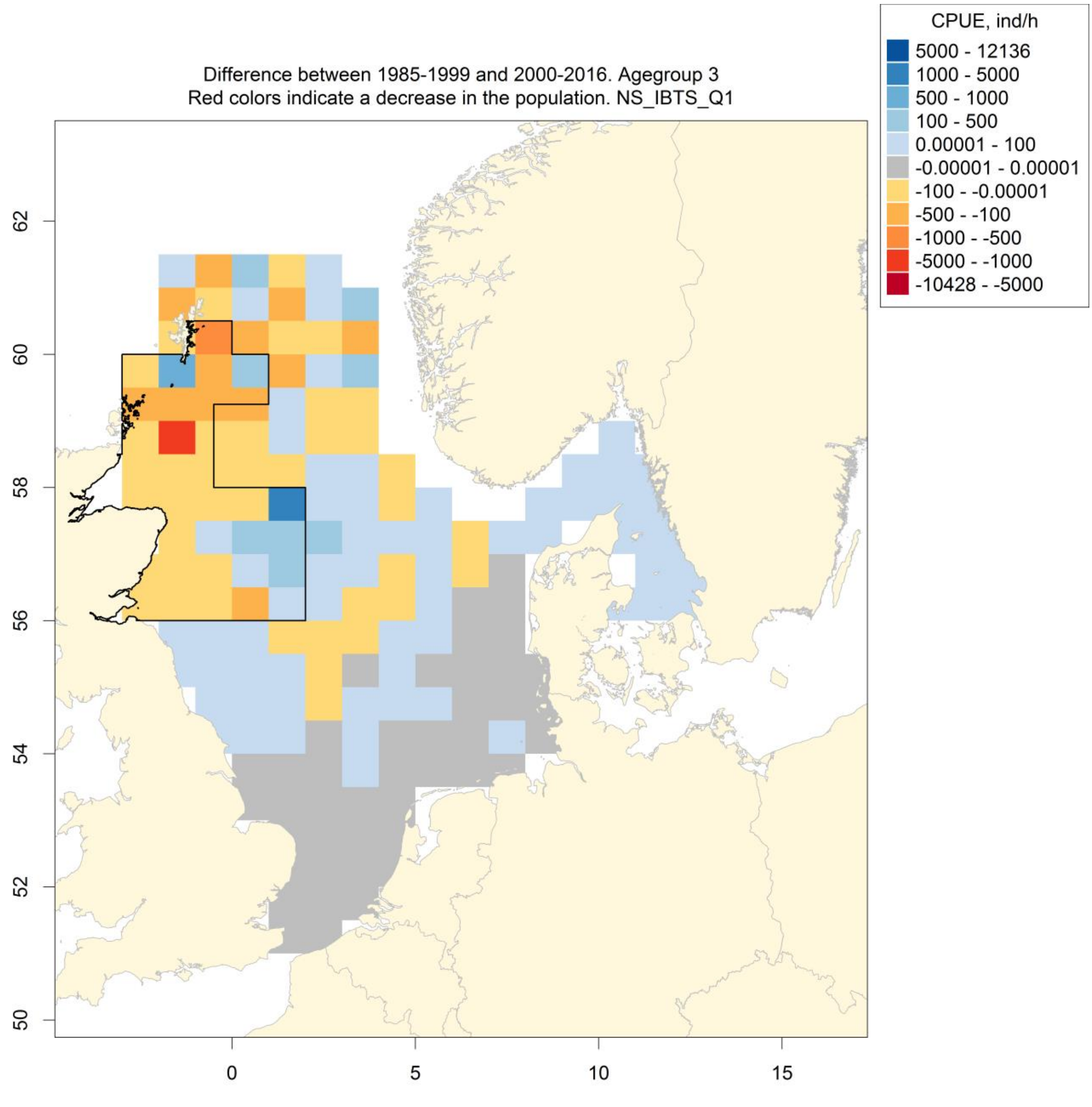


Figure 1. (Continued).



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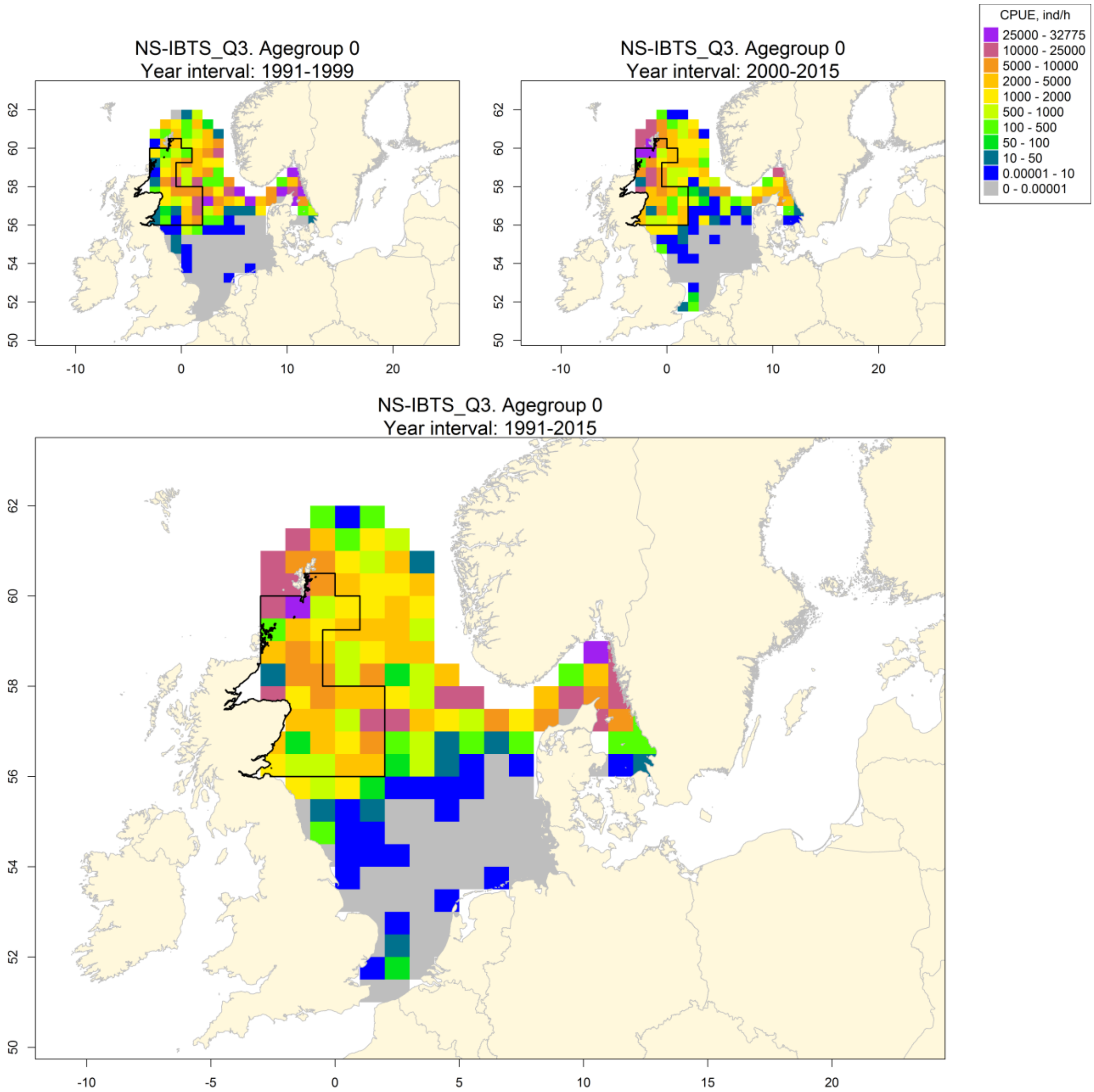
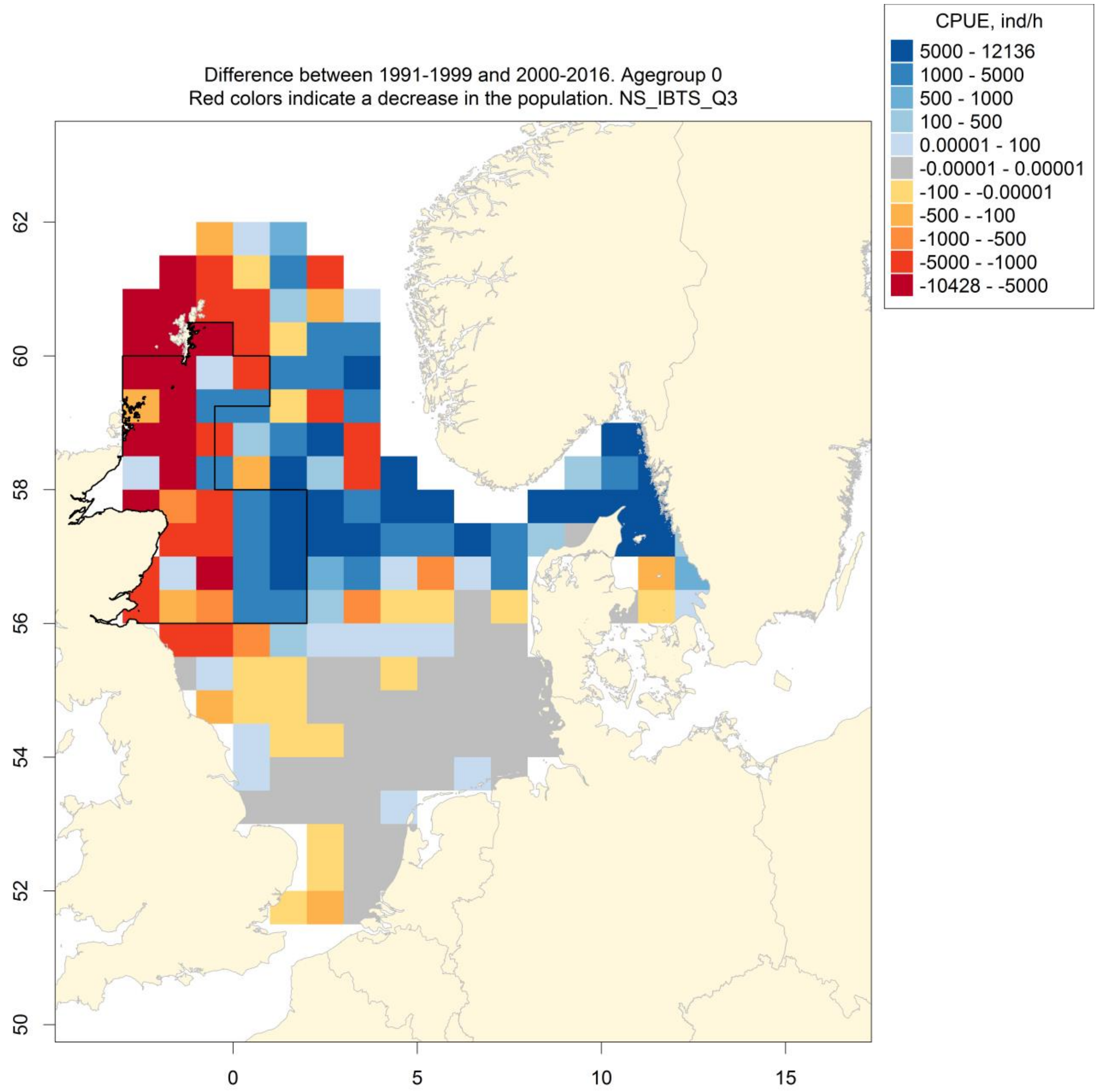


Figure 2. Catch per unit of effort (No/h) of Norway pout by age, ICES rectangle, (quarter) and time period for the IBTS Quarter 3 survey (IBTS Q3) in the period 1991-2015. Furthermore, the difference in CPUE per time period is shown in the figure on the next page. The “Norway pout box” is shown on the maps.



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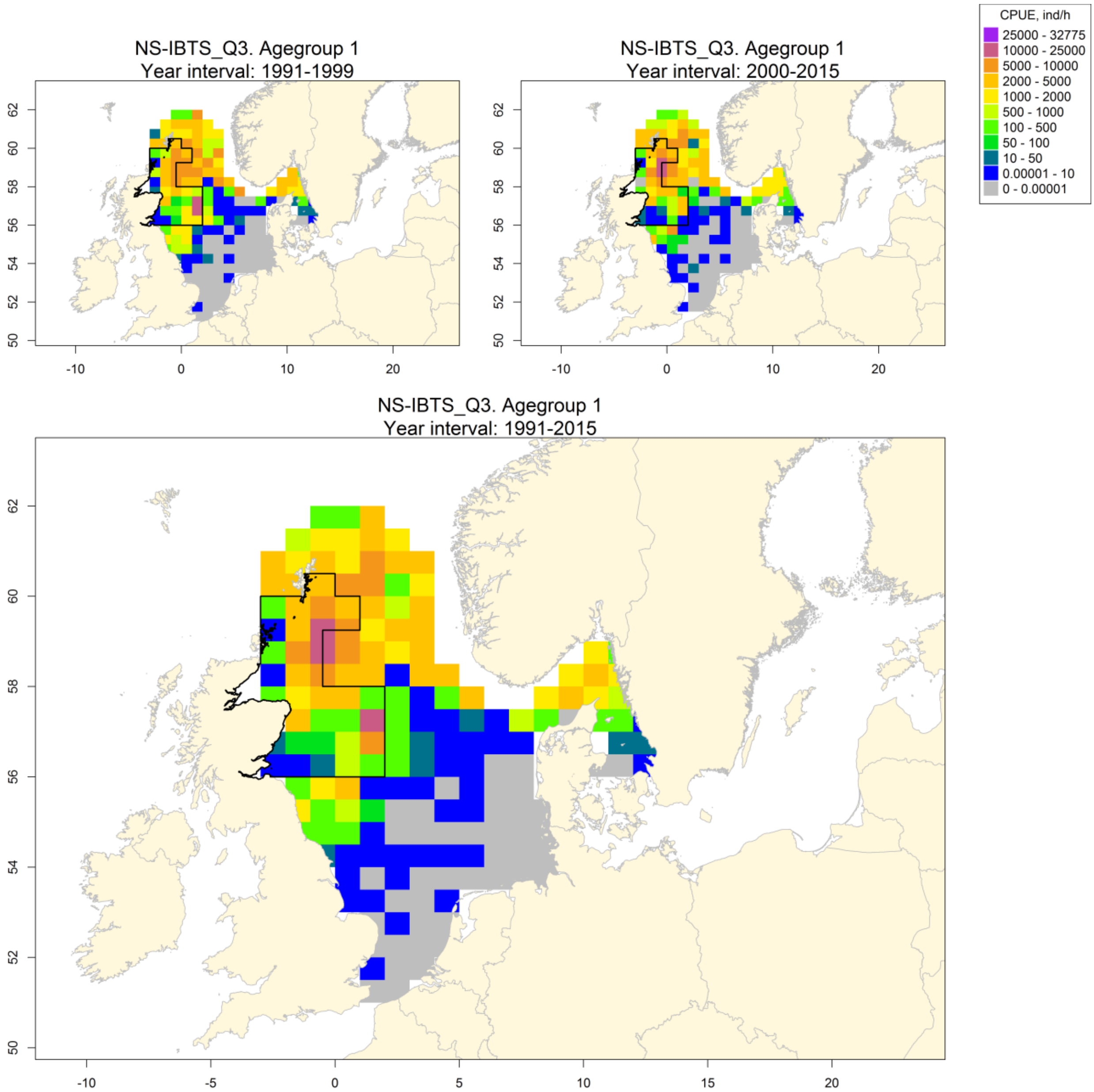

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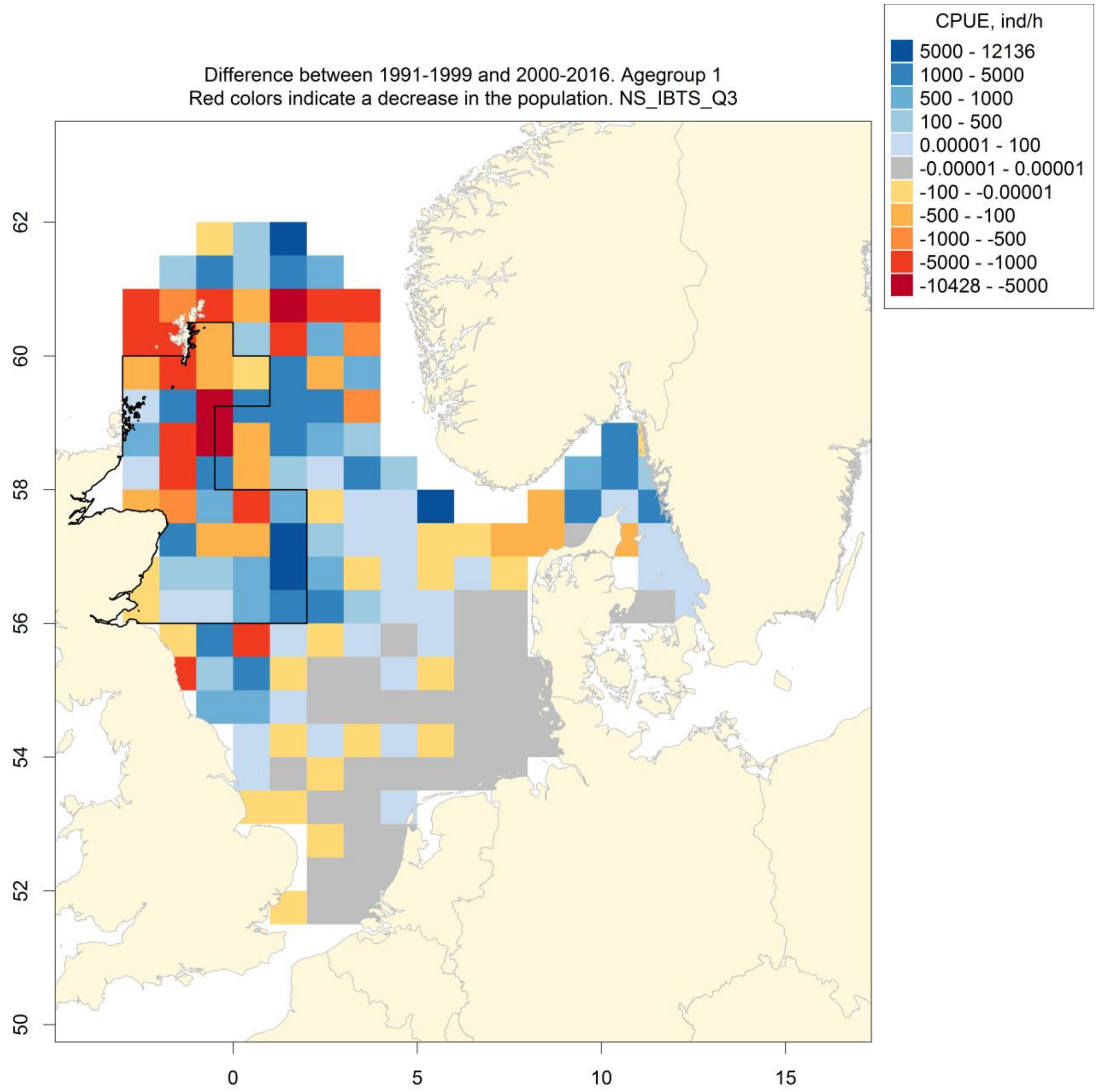

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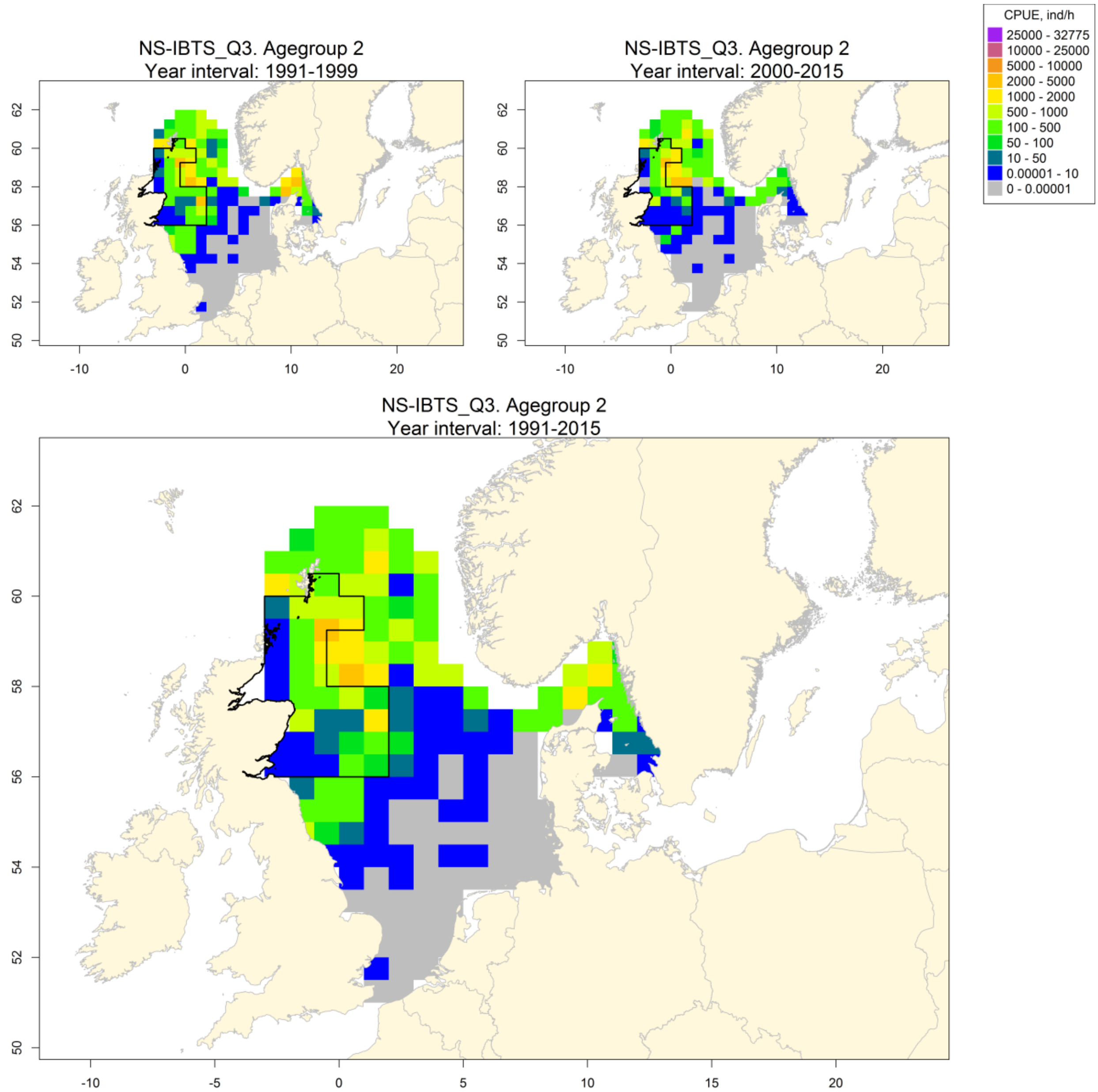

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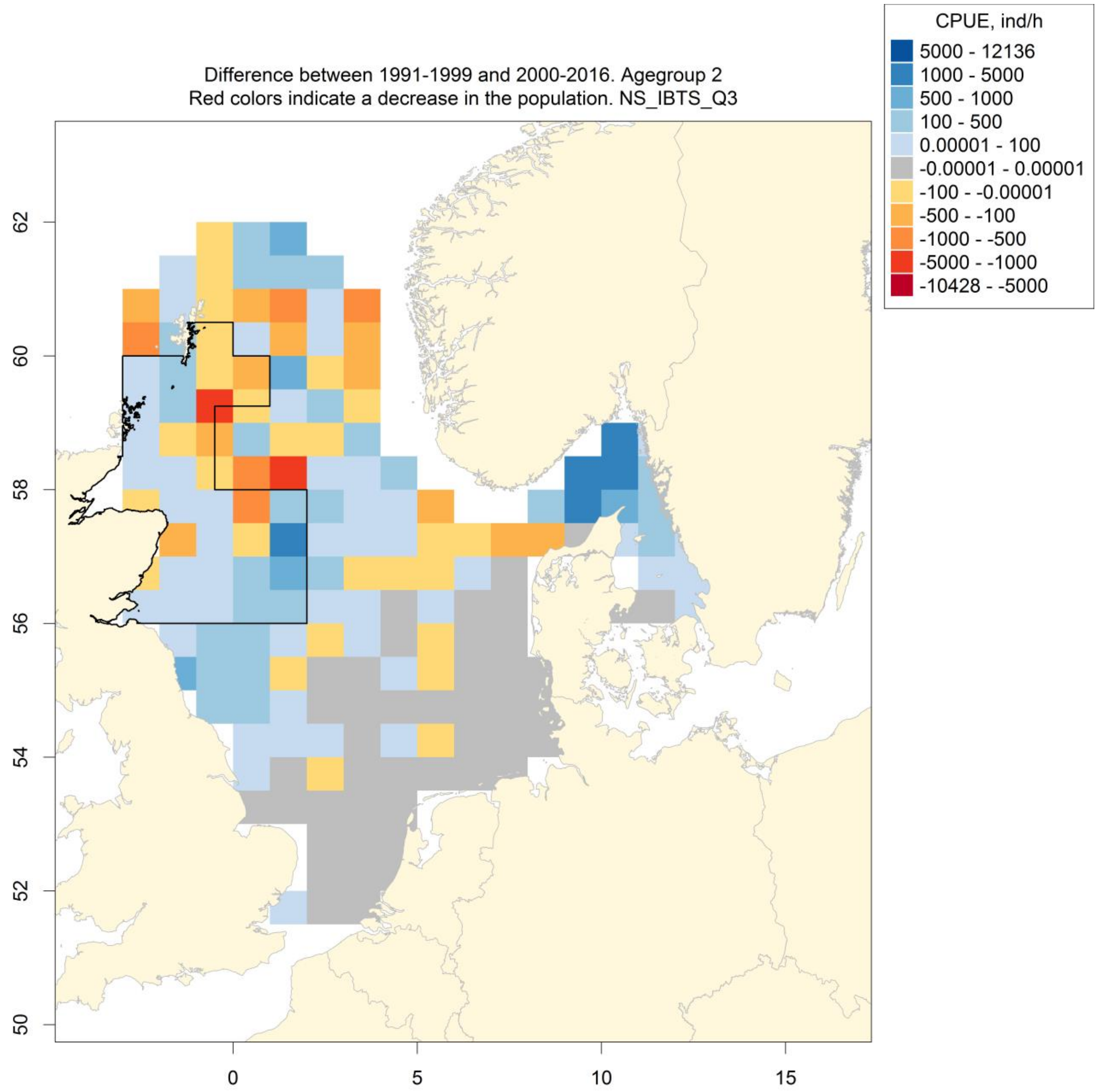

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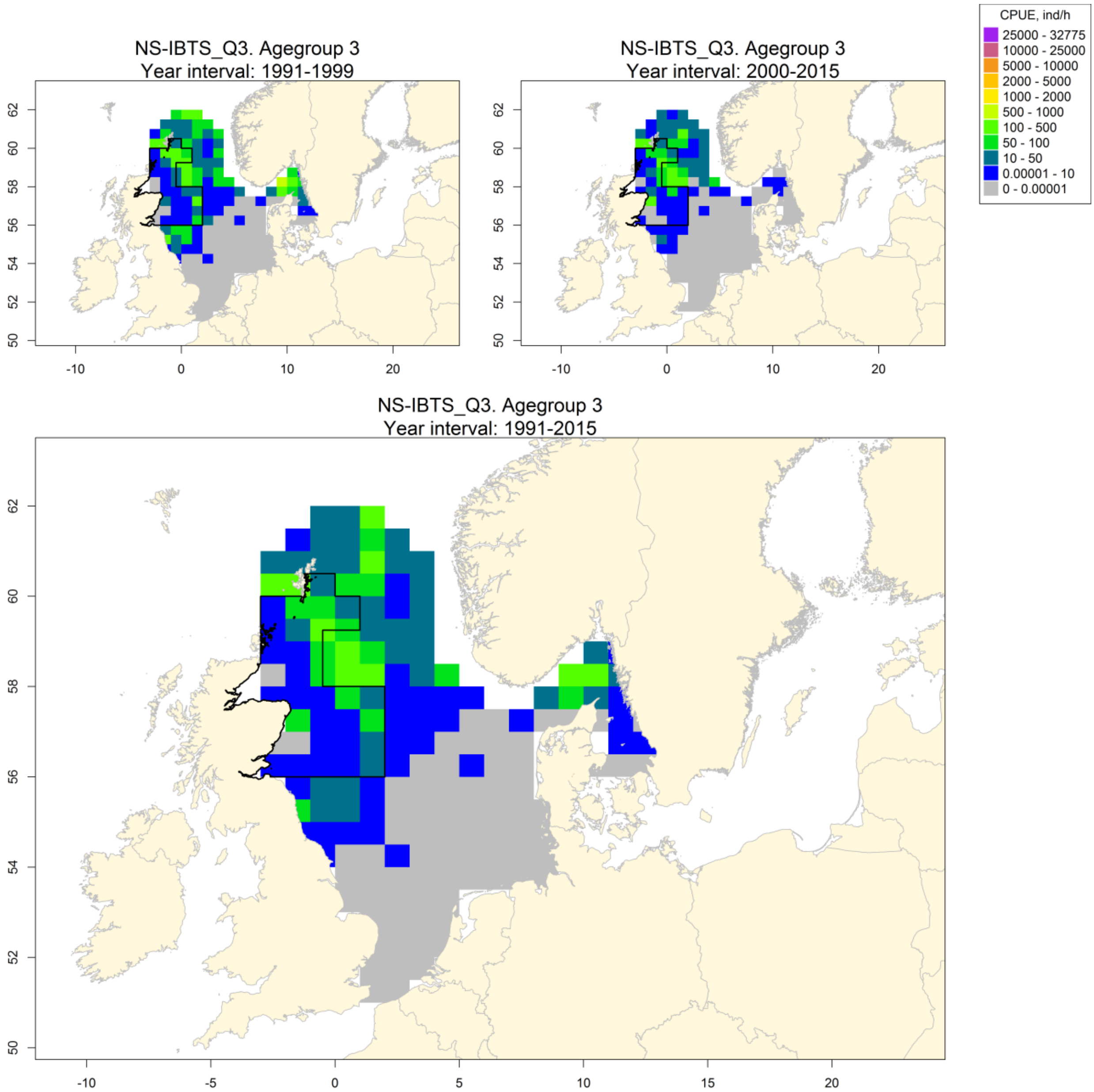

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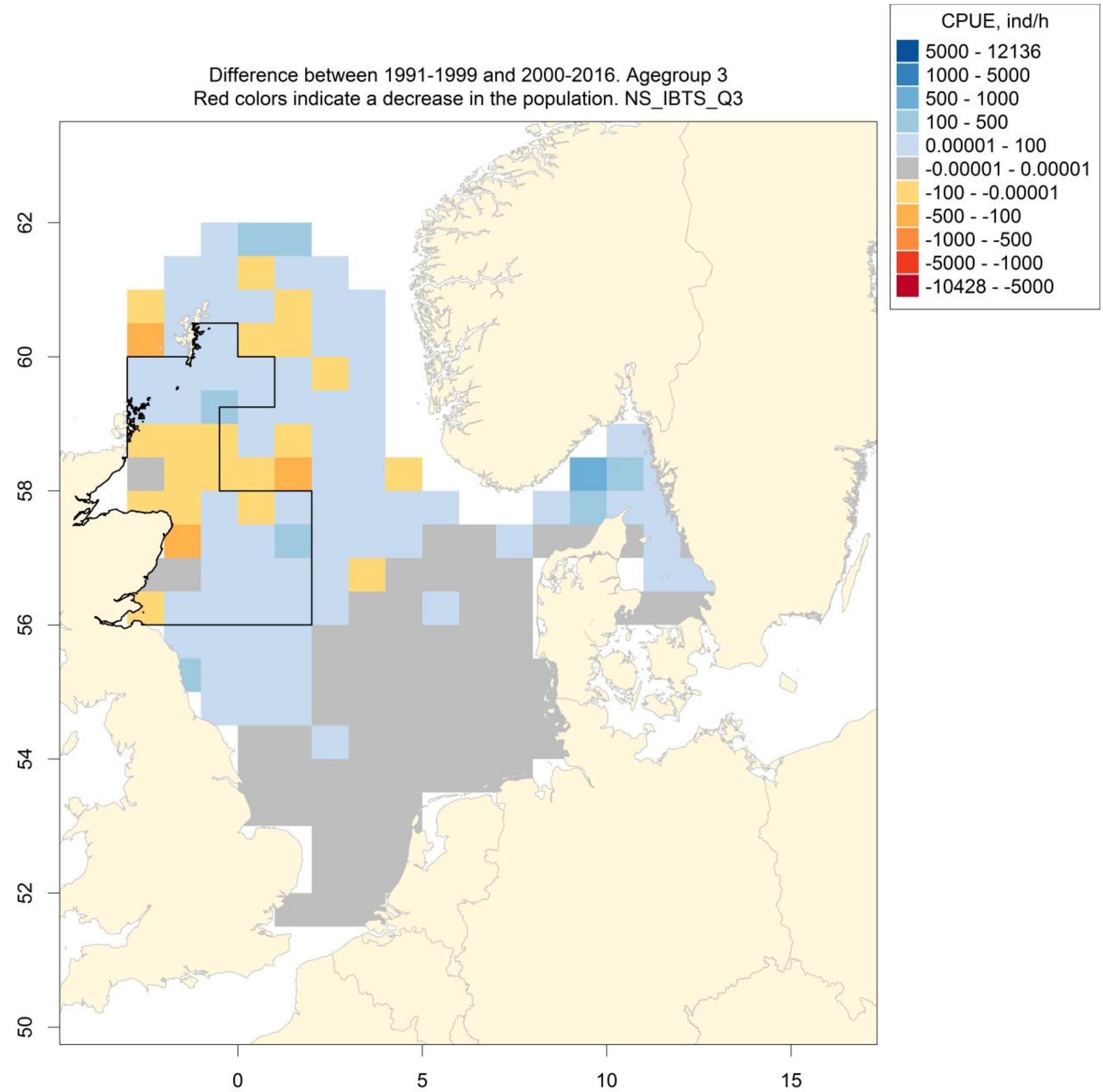

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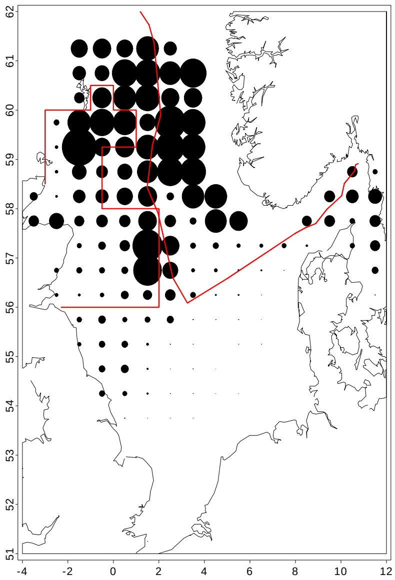
IBTS Quarter 1 IBTS Quarter 3



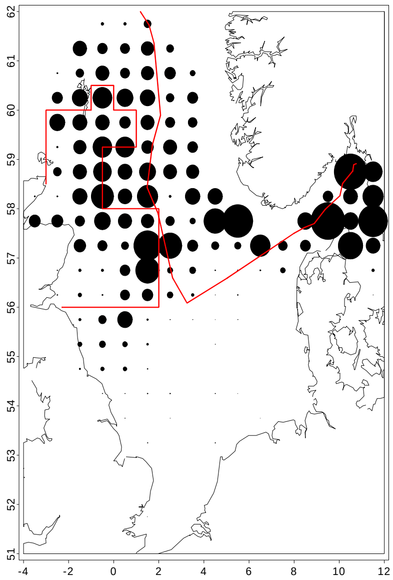


Figure 3. IBTS mean CPUE (numbers per hour) by quarter during the period 1991-2004. The area of the circles is proportional to CPUE. The IBTS surveys do only cover areas within the 200 m depth zone. The "Norway pout box" and the boundary between the EU and the Norwegian EEZ are shown on the map. The maps are scaled individually. (From EU 2007).

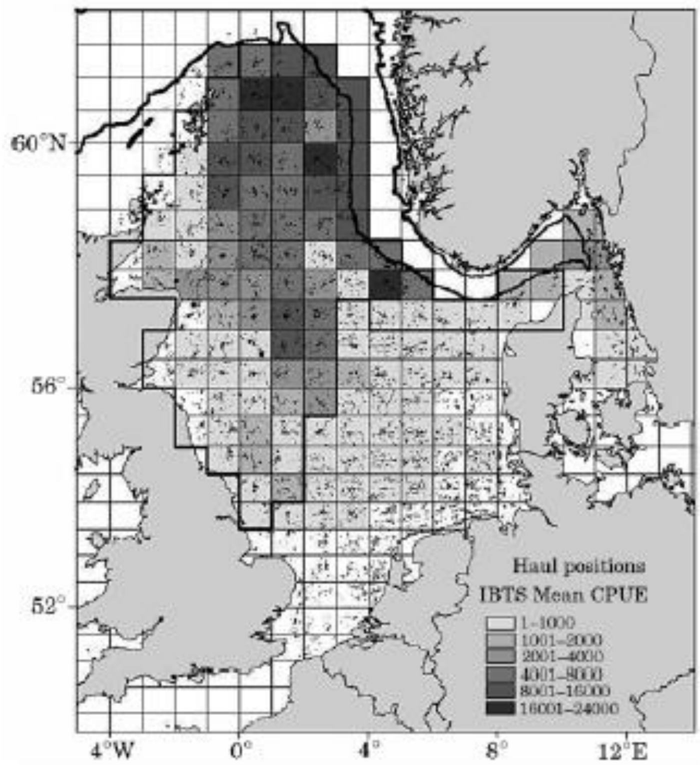


Figure 4. Positions fished at the International Bottom Trawl Survey (IBTS) first quarter and mean CPUE (numbers) of Norway pout by rectangle, 1981–1999. The standard area used to calculate abundance indices and the 200 m depth contour is also shown (from Sparholt *et al.*, 2002b).

3. Maturity, spawning, spawning distribution and migration

Maturity and spawning

Previously, it has been evaluated that around 10 % of the Norway pout reach maturity already at age 1, and that most individuals reach maturity at age 2. Results in Lambert *et al* (2009) show that the maturity rate for the 1-group is close to 20% in average (varying between years and sex) with an increasing tendency over the last 20 years (**Figure 5**). Furthermore, the average maturity rate for 2- and 3-groups in 1st quarter of the year was observed to be around 90% and 95%, respectively, as compared to 100% used in the assessment (**Figures 6-7**).

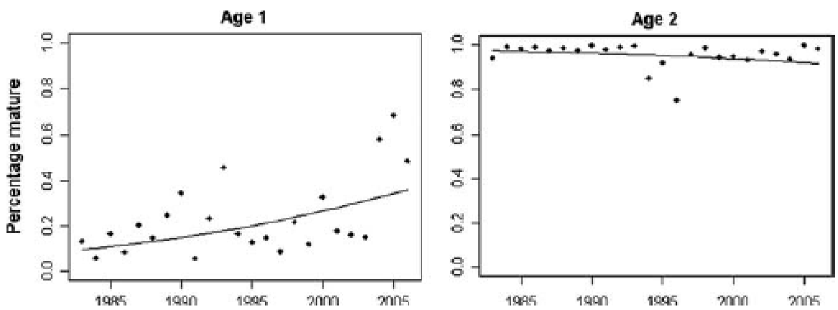


Figure 5. Temporal variability in the maturity ratio of Norway pout during Q1 at ages 1 (left) and 2 (right) from 1983-2006. (From Lambert et al. 2009).

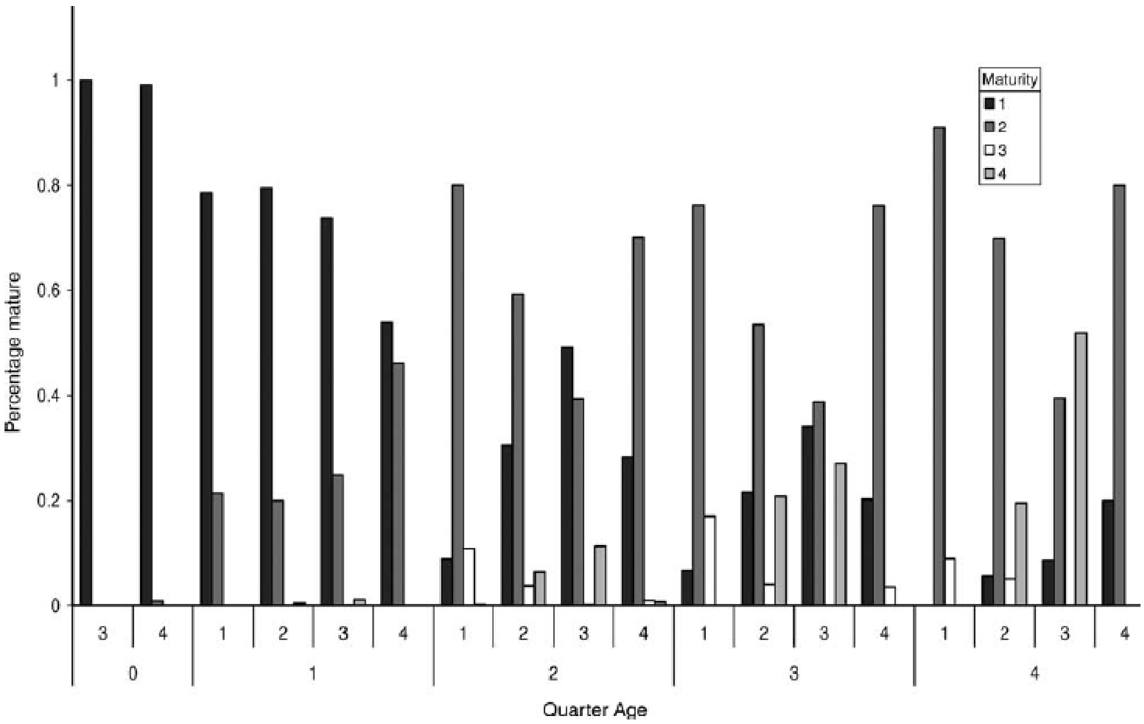


Figure 6. Percentage of each maturity stage (1-4) of Norway pout per age and quarter, based on data collected in Roundfish areas 1-4 and 7 in the North Sea between 1991-1997. (From Lambert et al. 2009)

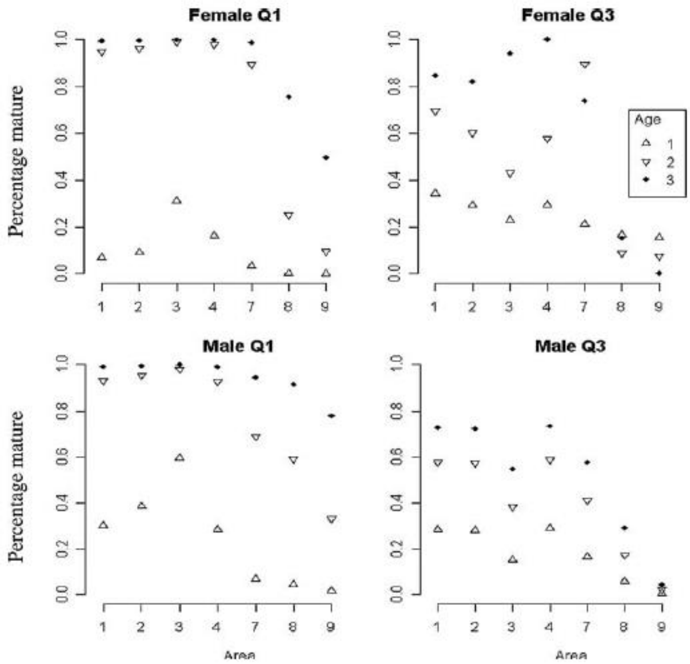


Figure 7. Maturity ratios for Norway pout in Q1 (left) and Q3 (right) after 1991: interaction age – area for males (bottom) and females (top). (From Lambert et al. 2009).

Sexual differences in maturity, growth, and numbers are expected from indications in the literature, and previous to 2009 the maturity of the stock has not been studied systematically, and the differences between the sexes were not known (Lambert *et al.* 2009). Female Norway pout are larger than males (Raitt, 1968), and several authors (e.g. Heesen and Kuiter, 1982; Cooper, 1983; ICES, 2007b) have reported a numerical dominance of females which, according to Cooper (1983), increases with age. According to Lambert et al. (2009) growth is variable, with a tendency for male maximum length to be smaller than that of females (**Figures 8-10**), and immature fish to be smaller than mature ones in each age group. Sex ratios indicate that males mature younger than females (age-at-50%-maturity, respectively, 1.2 and 1.5 years) and there is a decrease in the 2+-group maturity ratios as well as in weight and female length from before to after spawning (**Figures 11-12**). Among other these results indicate spawning mortality, and that Norway pout is most likely a short-lived one-time spawning species (Lambert et al. 2009; Nielsen et al. 2012; see also under **Section 5** below).

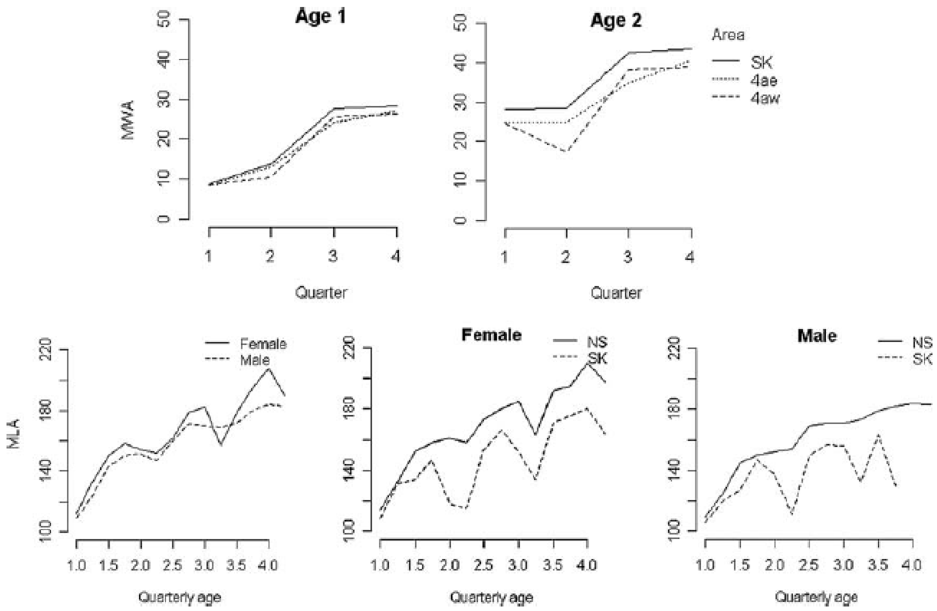


Figure 8. Top panels: quarterly evolution of MWA at ages 1 and 2 in areas 4ae (eastern North Sea), 4aw (western North Sea), and SK (Skagerrak–Kattegat), based on data for the period 1983–2004. Bottom panels: evolution of mean length-at-quarterly-age (MLA by quarter, where age 1 in Q1 = 1.00, and age 1 in Q2 = 1.25, etc.) for males and females in the North Sea and Skagerrak and Kattegat, based on data for the period 1991–1996. (From Lambert et al. 2009).

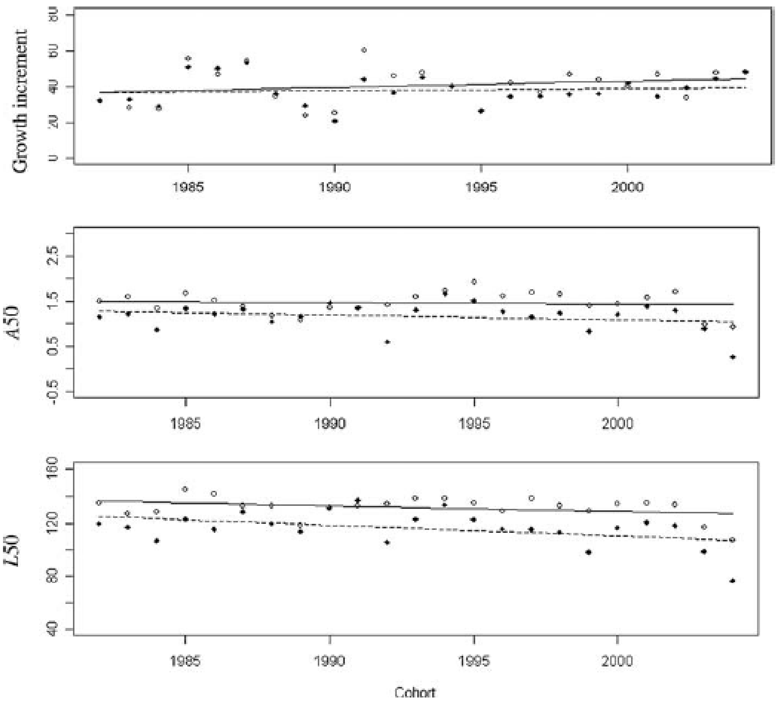


Figure 9. Temporal trends in growth increment for each cohort from age to age+1 (cm per year), A50, and L50, by sex. Black dots and dashed lines, males; white circles and continuous lines, females. (From Lambert et al. 2009).

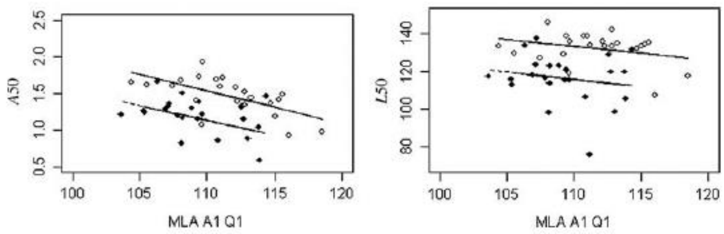


Figure 10. Correlation between A50 (left) or L50 (right) and MLA for age 1 in Q1. Black dots and dashed lines, males; white circles and continuous lines, females. (From Lambert et al. 2009).

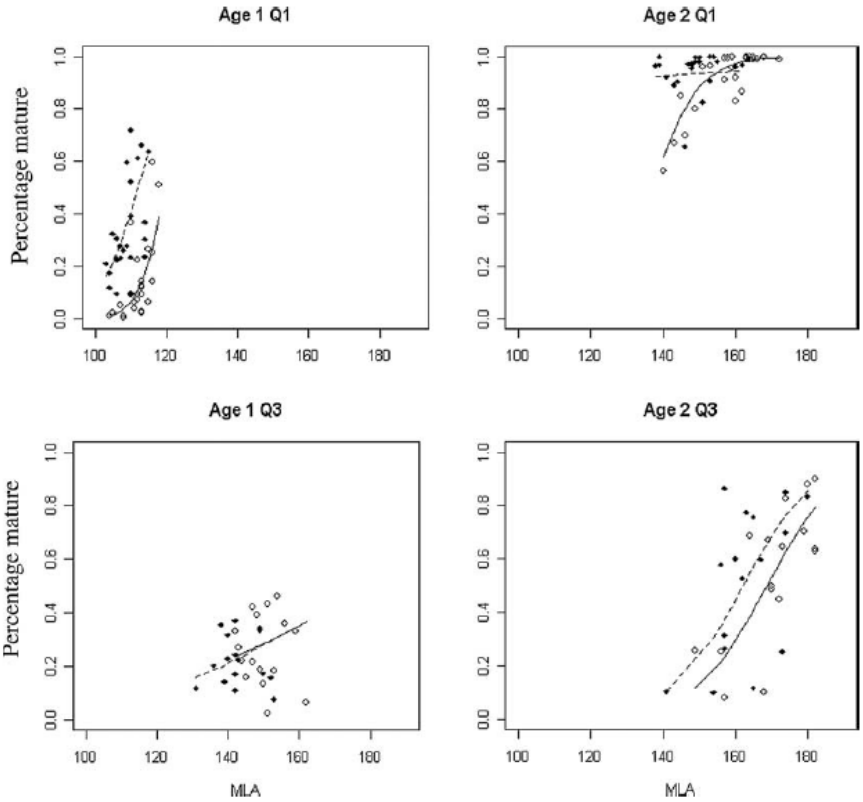


Figure 11. Relationships between the percentage of mature fish and MLA in mm (age 1 Q1 males p<0,001, females p<0,001; age 2 Q1 males not significant, females p<0,001; age 1 Q3 males not significant, females not significant, age 2 Q3 males not significant, females p<0,001). Black dots and dashed lines males; white circles and continuous lines females. (From Lambert et al. 2009).

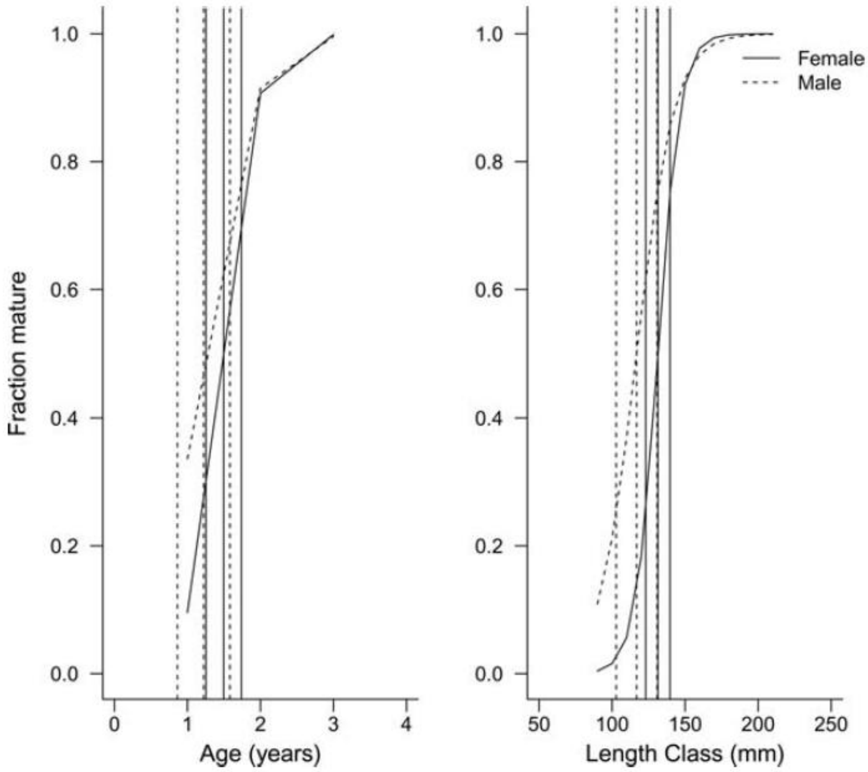


Figure 12. Fraction mature as functions of age [logit(p) = a + b × age] (left) and length [logit(p) = a + b × length] (right). Females, continuous lines; males, dashed lines; LC, length class. Vertical lines represent the age at 25, 50, and 75% maturity. (From Lambert et al. 2009 & Nielsen et al. 2012).

The actual decrease in the maturity ratio from Q1 to Q3 in age groups 2+ reinforces the hypothesis of spawning being mainly in the first quarter, and followed by significant spawning mortality (Lambert et al. 2009; Nielsen et al. 2012). If there was no spawning mortality, higher frequencies (than actually observed) of spawning (M3 or M4) fish would be expected from the fishery or observed at least once during the long time series of surveys throughout the North Sea in Q1, which was not the case (Lambert et al. 2009; Nielsen et al. 2012). The scarcity of M4 Norway pout in Q2 and Q3 and the total absence of M4 in Q4 can also be explained by spawning mortality, but a return to M2 cannot be excluded as a potential explanation. This means that the possibility of misidentifying M2 and M4 gonad stages also has to be considered (Lambert et al. 2009). Compared with age 1, there was a notable decrease in MWA in the western North Sea from Q1 to Q2 for age 2, which was obviously linked to spawning (Lambert et al. 2009). In general, the lack of growth in weight from Q1 to Q2 and the observed decline in MLA from Q1 to Q2 likely indicate spawning mortality because the spawning and the loss of spawning products will affect the largest fish most, resulting in a decreased MLA (Lambert et al. 2009). If the loss in weight was due, for instance, to food scarcity (perhaps leading to mortality), one would not expect a decrease in MLA because of greater mortality among the bigger fish. The analyses in Lambert et al. (2009) did not give strong evidence of spawning mortality, but the results are still indicative of this, especially for females. Male Linf was in general smaller than female Linf,, in accord with Raitt (1968), and immature fish were generally smaller than mature fish. However, the growth rates, computed with the von Bertalanffy growth equation, could not be distinguished between the sexes. This would explain why males attain maturity before females and why males dominated the maturity ratio at age 1 in Q1 (to some 70%) (Lambert et al. 2009).

With respect to intra-specific interactions and potential density dependency, the juvenile growth rate is higher when the stock density is low (**Figures 13-14**) and results in a reduced age-at-50%-maturity (Lambert et al. 2009; Nielsen et al. 2012; **Figures 15-17**). When density is high at age 0 in Q4, the maturity ratio tends to be lower in the subsequent quarter, i.e. at age 1 in Q1 of the succeeding year (Lambert et al. 2009). The percentage of mature fish by sex, weighted by CPUE indices, gives an indication of the ratio of mature fish in the stock. Lambert *et al.* (2009) found that these percentages of mature females and males aged 2 in Q1 compared well with the pattern observed at age 1. The slope decreased significantly for males at age 2 when recruitment increases. Even if the other relationships tested (e.g. age group 1 by sex, with recruitment from the previous quarter, for instance) were not significant, they showed the same trend of decreasing maturity corresponding to an increase in the levels of recruitment. (Lambert et al. 2009).

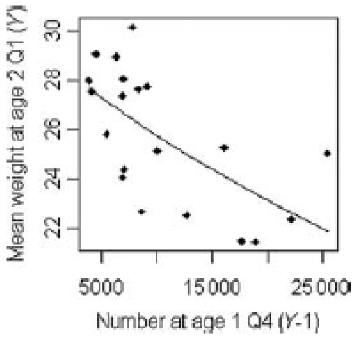


Figure 13. Relationship (p , 0.01) between MWA at age 2 in Q1 and the number of fish from the same cohort in the previous quarter (MWA at age 1 in Q4). (From Lambert et al. 2009).

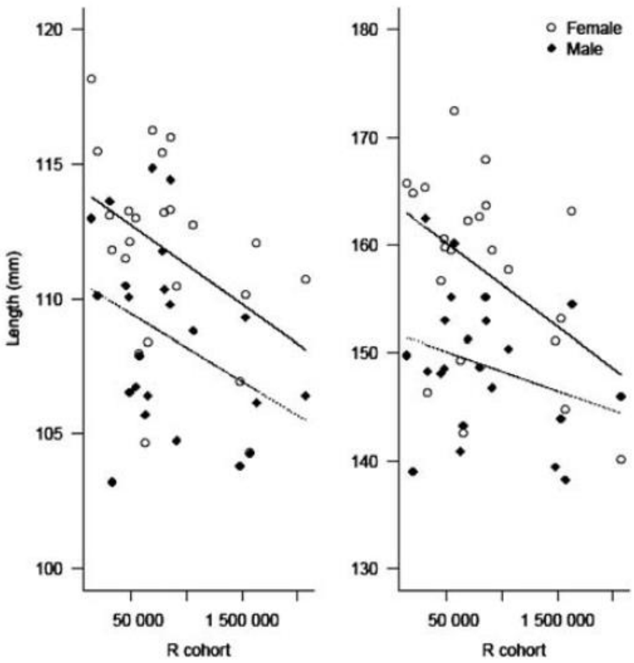


Figure 14. Mean length-at-age in Q1 of age 1 (left) and of age 2 in Q1 (right) vs. year-class strength [recruitment (R) of a cohort] showing statistically significant intraspecific density-dependence. Females, white circles and continuous lines; males, black dots and dashed lines; cohorts in millions. (From Lambert et al. 2009 and Nielsen et al. 2012).

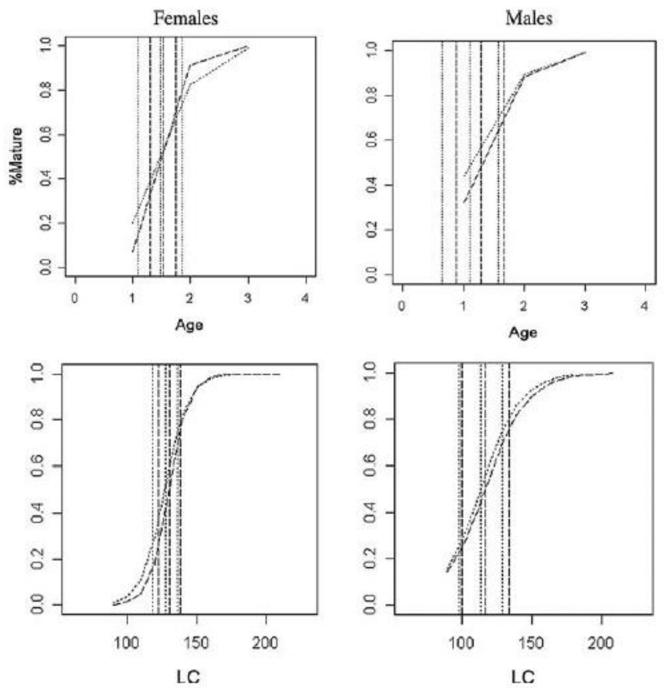


Figure 15. Maturity ogives by age (top) and length (bottom), and comparison between weak and strong year classes for each sex. Dotted lines, weak year classes; long-dashed lines, strong year classes; LC, length class. (From Lambert et al. 2009).

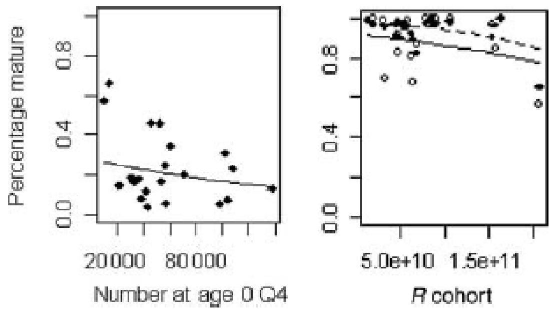


Figure 16. Statistically significant intraspecific relationship between maturity ratio at age 1 in Q1 and the number of fish aged 0 in the previous quarter (sexes combined), and between maturity ratio at 2 in Q1 and recruitment of the current cohort (subdivided by sex). Black dots and dashed lines, males; white circles and continuous lines, females. (From Lambert et al. 2009).

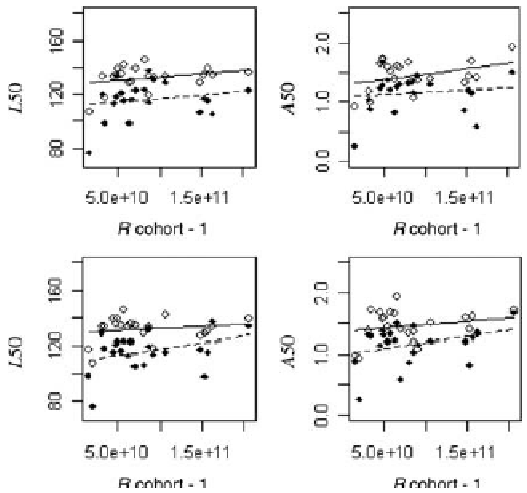


Figure 17. Correlations between L50 or A50 and recruitment number of the previous (top) and current (bottom) cohorts. Black dots and dashed lines, males; white circles and continuous lines, females. (From Lambert et al. 2009).

According to the above, 20% of age 1 is estimated mature and is included in the SSB. Therefore, the recruitment in the year after the assessment year influences the SSB already in the following year and very much in the second year. Recruitment is highly variable and influences SSB and total stock biomass (TSB) rapidly because of the short life span of the species. Consequently, the population dynamics of Norway pout in the North Sea and Skagerrak are very dependent on changes caused by spawning and recruitment variation as well as variation in predation (or other natural) mortality, and less by the fishery (Nielsen *et al.*, 2012; Lambert *et al.* 2009; Sparholt *et al.*, 2002a, 2002b; Lambert *et al.*, 2009).

The ICES inter-benchmark assessment in spring 2012 (IBPNorwayPout, ICES 2012c) introduce revised estimates of maturity and natural mortality at age used in the Norway pout stock assessment. The background and rationale behind the revision of the natural mortality and maturity parameters is described in the IBPNorwayPout report (ICES, 2012c) and primary literature (e.g. Nielsen *et al.*, 2012; Lambert *et al.*, 2009; ICES WGSAM 2011)).

The same proportion mature and natural mortality are used for all years in the assessment. The proportion mature used is 0% for the 0-group, 20% of the 1-group and 100% of the 2+-group independent of sex. The revisions of the maturity ogive which have been implemented in the 2012 inter-benchmark assessment and following assessments based on results from Lambert *et al.* (2009) indicating that the maturity rate for the 1-group is close to 20% in average (varying between years and sex) with an increasing tendency over the last 20 years. Furthermore, the average maturity rate for 2- and 3-groups in 1st quarter of the year was observed to be only around 95% as compared to 100% used in the assessment.

Spawning distribution

Figures 1 and **2** and **Appendix A.1** and **A.2** show geographical distribution of the stock by age group obtained from the ICES IBTS surveys. The IBTS Surveys only cover areas within the 200 m depth zone. For the Norwegian Trench, Albert (1994) found Norway pout at depths greater than 200 m, but very few deeper than 300 m. It appears from **Figure 2** and **Appendix A.2** that age group 0 observed in the third quarter of the year (IBTS Q3) has high density in the Northern part of the North Sea between Shetland and Norway, as well as relative high density in the Skagerrak area in the third quarter, where the 0-group is a very important part of the catches.

The results in Lambert et al. (2009) have contributed to a more detailed understanding of spawning time and area for Norway pout in the North Sea and Skagerrak. In **Figure 18** the distribution of spawning Norway pout is shown as observed in the ICES IBTS surveys between 1983 and 2007 given as sums of all fish observed for all quarters (Lambert et al. 2009). Such direct observations of spawning give information on spawning areas, but are only indicative of overall general spawning intensity. This analysis of historical IBTS data indicate main spawning in the northern North Sea and revealed that most of the spawners sampled (**Figure 18**) were around the Viking Bank (mainly in Roundfish areas 1 and 3, **Figure 185**) and along the eastern Scottish coast during Q1 (Lambert et al. 2009). However, the area of observation did not include the Norwegian coast. Throughout the 15 years of surveys, only few spawning Norway pout were found in the Skagerrak and the Kattegat, indicating that although spawning may take place in the area, it is certainly not an important spawning ground. It has been assumed until now that spawning is negligible there (Poulsen, 1968) and that the adult part of the stock migrates out of that area to spawn (Poulsen, 1968; Albert, 1994). From the results in Lambert *et al.* (2009) it appears that age 1 spawning only takes place in shallower water along the north coast of England. The found distribution indicates that there might be some combined depth- and age-dependent patterns in spawning. A number of authors (e.g. Poulsen, 1968; Raitt and Mason, 1968) has stated that the preferred depth of occurrence for Norway pout increases with age. This is consistent with the results in Lambert et al. (2009).

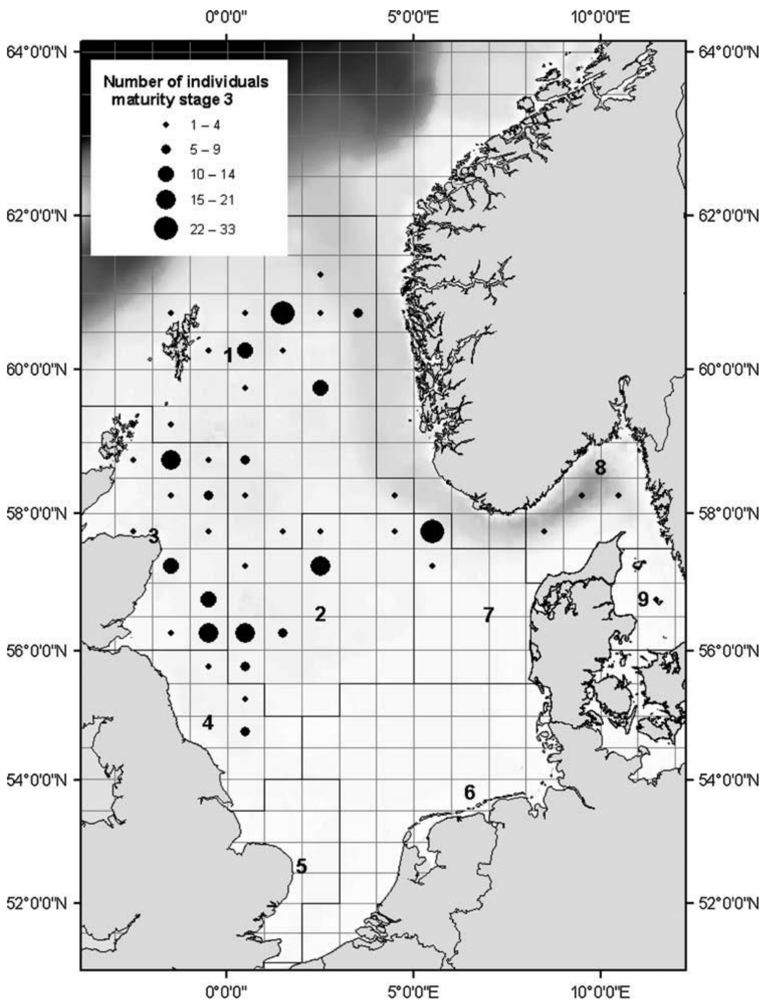


Figure 18. Distribution and numbers of spawning Norway pout collected during the ICES IBTS surveys (GOV and GRT Trawls) between 1983and 2007 (values are sums of all fish observed for all quarters). (From Lambert et al. 2009).

The distribution of spawning (and 0-group) Norway pout from the IBTS surveys was in Lambert et al. (2009) compared with the results from northern North Sea ichthyoplankton surveys (ICES, 2007a), which confirm the general spatio-temporal patterns of spawning. Norway pout larvae were found in the North Sea during surveys from 18 February to 23 March 2004. Their eggs, observed over a large area of the northern North Sea, were found for 2 weeks, and the newly hatched larvae were not caught after 30 days. Furthermore, Munk et al. (1999) surveyed juvenile abundance of gadoids in the central North Sea and Skagerrak–Kattegat during annual surveys conducted in May from 1991 to 1994 by three international research vessels. Although there was great variation between years, juvenile Norway pout were generally abundant everywhere in the surveyed areas, so it may be assumed that the larvae found in the Skagerrak were brought there by south-flowing currents from a spawning area around the Viking Bank. Consequently, Lambert et al. (2009) believe it is reasonable to assume that most spawning takes place in Q1, possibly in mid-February, because no evidence of later spawning has been found, and along the 120-m isobath off Norway (along the Norwegian Trench) and the Scottish Coast (ICES, 2007a; Lambert et al. 2009). In **Figure 19** the 120 isocline in the North Sea area is shown (present study).

Figure 19. GIS Chart of the distribution of the 120 m isocline in the northern North Sea and the deeper area outside the North Sea shelf. (Present study).

Based on IBTS data, the main aggregations of settled fish are distributed around the 150 m contour, with a slight preference for deeper water for the older fish (Lambert et al. 2009).

The above results supports earlier indications in literature of Norway pout spawning stating that Norway pout spawn in the North Sea between January and March mainly over the deeper parts of the northern North Sea (>100 m), with a peak in spawning occurring between March and April (Ehrenbaum, 1905–09 cited in Russell, 1976; Hislop, 1984), with the more northern populations (off the northwest coast of Norway) starting to spawn in late March and continuing through to June (Baranenkova and Khokhlina 1968 cited in Nash et al. 2012).

Huse et al. (2008) investigated correlation between Norway pout recruitment and herring spawning stock biomass in the North Sea through analyses of the spatial distributions and overlap of abundances of herring and Norway pout. The distribution of Norway pout recruits were estimated from survey indices of mature fish per ICES rectangle derived from the quarter 1 International Bottom Trawl Survey (IBTS) for the period 1982–2006. According to Huse et al. (2008), the survey takes place in February just before the peak in hatching of Norway pout, in early April (Heath, 2007), and is therefore relevant to estimating overlap between Norway pout eggs and larvae and potential predators. On this basis Huse et al. (2008) indicate a main spawning area of Norway pout in the North Sea as shown in **Figure 20** below.

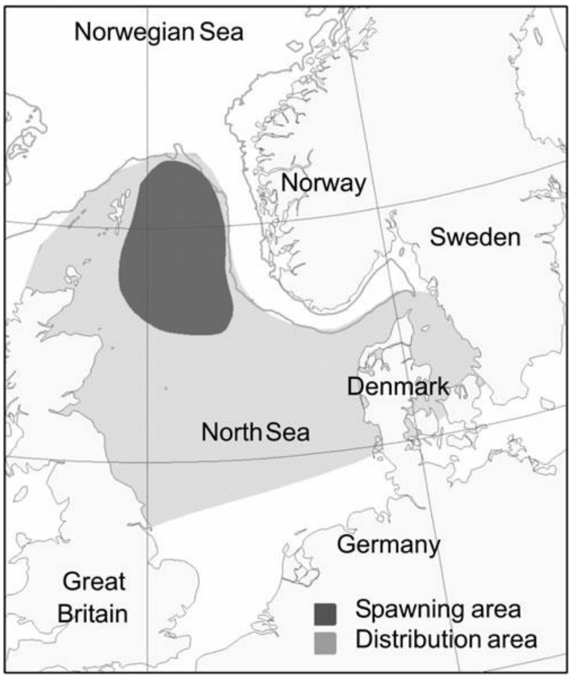


Figure 20. Distribution of Norway pout in the North Sea and indication of Norway pout spawning area in the North Sea according to Huse et al. (2008). The 200-m isobath is shown (from Huse et al. 2008).

Consequently, a number of authors state that Norway pout in the North Sea have spawns from mid-February/March to April (Raitt and Mason, 1968; Albert, 1994; Lambert et al. 2009) and mainly in the northern North Sea between Shetland and Norway. Lambert et al. (2009) suggest that the eggs and larvae drift away from the western spawning grounds generally towards the south and east. As Norway pout spawn in the water column and there is no clear evidence of large spawning aggregations (Lambert et al. 2009), ichthyoplankton surveys may offer a more reliable approach for mapping spawning locations (Nash et al. 2012). Both ichthyoplankton and trawl survey data have been used to map the distribution of spawning aggregations (ICES, 2006, 2007a). However, as eggs and larvae can be dispersed by currents, the identification of spawning areas is reliant on the correct identification of early stage eggs (Nash et al. 2012 and references herein). According to Nash et al. (2012) conducting comparative analyses of ICES ichthyoplankton and IBTS surveys the distribution of Norway pout stage I eggs in 2009 revealed the distribution of spawning in the North Sea and showed that it was similar to the distribution of 2 + Norway pout taken during the International Bottom Trawl Surveys (IBTS) over the same period covering the whole North Sea. The larvae sampled in 2010 were largely in the same area (Nash et al. 2012); however, larger larvae occurred to the south-east of the survey area, suggesting advection of young stages from the principal spawning areas in the north-western North Sea to the south-east and toward the Skagerrak (Nash et al. 2012).

By apportioning the number of Norway pout eggs as determined through molecular analyses to the total number of stage I gadoid eggs subsampled at plankton stations in the above ICES ichthyoplankton surveys, Nash et al. (2009) regenerated the distribution of Norway pout spawning locations in 2009. These data were compared with the distribution of age 2 + (potential spawning) Norway pout in January/March of the same year from IBTS surveys to assess whether trawl surveys do give a true indication of spawning extent. The links between adult and larval distribution were examined in 2010 based on the distribution of age 2 + Norway pout in January/March and then larvae were sampled in May (Nash et al. 2012). The results showed that the he highest concentrations of adultNorway pout in January/March 2009 were to the east and south-east of the Shetland Isles, with additional elevated concentrations occurring on the edge of the Norwegian trench to the south-west of Norway (**Figure 21a**). The highest concentrations of eggs matched the distribution of adults to the east and south-east of Shetland (**Figure 21b**; Nash et al. 2012). Eggs occurred along the western slope of the Norwegian trench; however, the distribution to the east is unknown as no sampling was carried out over the deep water along the Norwegian coast. Tests indicated that the egg and age 2 + density distributions were similar at the ICES rectangle scale. The pattern of adult Norway pout in January/March 2010 was similar to that of the previous year, again with elevated concentrations to the east and south-east of Shetland and to the south-west of Norway (**Figure 22a;** Nash et al. 2012). Similar to the egg distributions in 2009, the higher concentrations of larvae in 2010 were to the north and west of the survey region in the south and east vicinity of the Shetland and the Orkney Isles (**Figure 22b**). No larvae occurred in samples in the eastern section toward the entrance to the Skagerrak. (Nash et al. 2010).

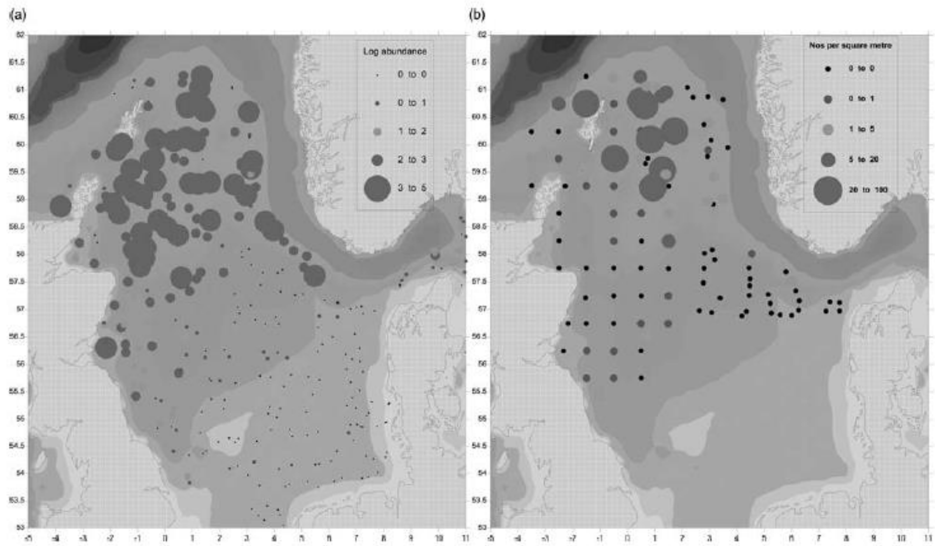


Figure 21. The distribution of Norway pout (*Trisopterus esmarkii*). (a) Adults (age 2 +) and (b)stage I eggs in the northern North Sea in January/March 2009. The size of the dot reflects the abundance on a logarithmic scale. Smallest (black) dots represent a complete absence. Depth contours are shaded. (From Nash et al. 2012).

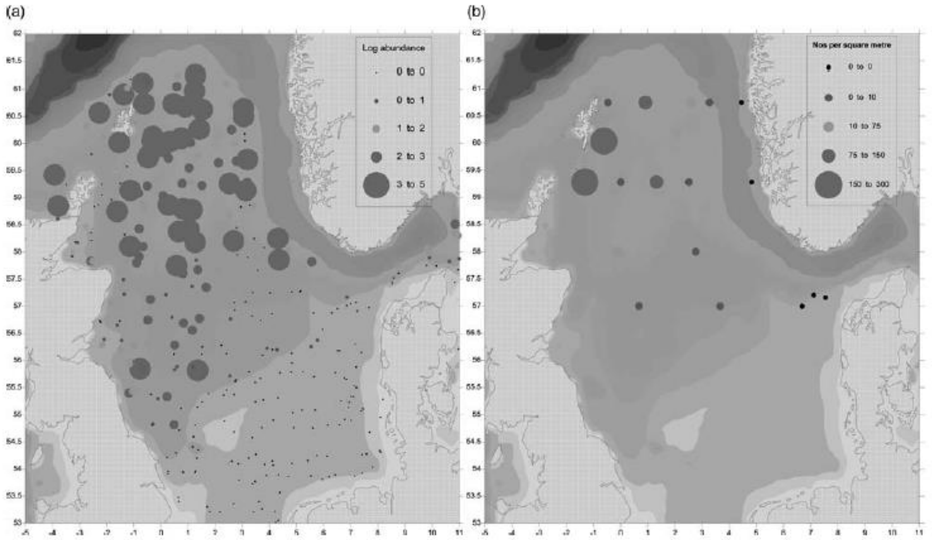


Figure 22. The distribution of Norway pout (*Trispoterus esmarkii*). (a) Adults (age 2 +) in January/March 2010 and (b) larvae in April/May 2010 in the northern North Sea. The size of the dot reflects the abundance on a logarithmic scale. Smallest (black) dots represent a complete absence. Depth contours are shaded. (From Nash et al. 2012).

Nursery areas

Larvae and juvenile distribution: The species is not generally considered to have specific nursery grounds, but pelagic 0-group fish remain widely dispersed in the northern North Sea close to spawning grounds (Poulsen 1968; Lambert *et al*., 2009; present study **Figures 2-3** and **Appendix A.2**). The main bulk drifts as larvae from more western areas to which they return mainly during the latter part of their second year of life before becoming mature (Poulsen 1968). In terms of the distribution of larvae and juveniles, Norway pout are generally not considered to have specific nursery grounds, but pelagic 0-group fish have been reported as being widely dispersed in the northern North Sea close to the spawning grounds (Poulsen, 1968). Most of the larvae seemingly drift from the more western areas to which they return mainly during the latter part of their second year of life before maturing (Poulsen, 1968).

The IBTS CPUE maps (**Figures 2-3** and **Appendix A.2**) shows, however, a relative high CPUE in the Skagerrak area in the third quarter, where the 0-group is a very important part of the catches. Nash et al. (2012) found that larger larvae occurred to the south-east of the survey area, suggesting advection of young stages from the principal spawning areas in the north-western North Sea to the south-east and toward the Skagerrak.

In general, this species is not considered to have specific nursery grounds (Lambert et al. 2009).

Adult (spawning) migration

There is an adult spawning migration out of Skagerrak and Kattegat to spawn because there is no evidence of spawning there (Poulsen 1968; Lambert et al. 2009). Sex ratios indicate that males, which mature younger than females (age-at-50%-maturity, respectively, 1.2 and 1.5 years), migrate out of the Skagerrak–Kattegat to the spawning grounds before females (Lambert et al. 2009). Albert (1994) stated that the negative winter growth in the Skagerrak reported by Ursin (1963) and Poulsen (1968) could be explained by emigration of the species. Otherwise there is no indication of adult migration (Lambert *et al*. 2009).

Lambert et al. (2009) showed that males dominated the maturity ratio at age 1 in Q1 (to some 70%). This maturity ratio was not spatially equitably distributed: the Skagerrak and the Kattegat remain the areas with the lowest maturity ratios, reinforcing our theory of a spawning migration that is sex-dependent. The migration is especially obvious when studying the temporal evolution of the MLA from Q3 to Q2. The decrease in length in the Skagerrak–Kattegat suggests that mature fish leave for the spawning grounds (Ursin, 1963; Albert, 1994). As males mature before females and the sex ratio tends to decrease from Q1 to Q3 in the Skagerrak–Kattegat and to increase from Q3 to Q1, whereas the opposite phenomenon occurs in the northern North Sea, one hypothesis would be that males migrate to spawn before females and that neither return, possibly as a result of spawning mortality. Even if this suggestion is logical, however, one cannot be definitive because the weighted mean sex ratios computed in Lambert et al. (2009) show high deviance and the results cannot prove what was assumed by Cooper (1983), who stated that there was an increasing numerical dominance of females with age. Moreover, these sex ratios found in Lambert et al. (2009) can be skewed by vertical migrations, as already recorded for other gadoids, such as cod (Armstrong et al., 2004).

4. Stock delineation and definition

Norway pout is a small, short-lived gadoid species, which rarely gets older than 5 years (Nielsen *et al.*, 2012, Lambert *et al,*, 2009). It is distributed from the west of Ireland to Kattegat, at the Faroe Islands, and from the North Sea to the Barents Sea. The distribution for this stock is in the northern North Sea (>57°N) and in Skagerrak at depths between 50 and 250 m (Raitt 1968; Sparholt *et al.*, 2002b). At present, there is no evidence for separating the North Sea component into smaller stock units (Lambert *et al.* 2009; Nash *et al.* 2012). ICES Advisory Committee for Fisheries Management (ACFM) asked in October 2001 the ICES Working Group on the Assessment of Demersal Stocks in the North Sea and Skagerrak (ICES WGNSSK) to verify the justification of treating ICES Division VIa as a management area for Norway pout (and sandeel) separately from ICES areas IV and IIIa. Preliminary results from an analysis of regionalized survey data on Norway pout maturity, presented in a Working Document to the 2000 meeting of the ICES WGNSSK Working Group (Larsen et al. 2001 in ICES C.M.2001/ACFM:07), gave no evidence for a stock separation in the whole northern area. This conclusion is supported by the results from the maturity and spawning analyses presented in Lambert *et al.* (2009) and Nash *et al.* (2012) as well as Huse *et al.* (2008). Here it was found that spawning in the North Sea takes place mainly in the northern part in the area between Shetland and Norway in coastal waters along the 120 m isocline (Lambert *et al.,* 2009). The results from Nash et al. (2012) also suggest one main spawning area and accordingly only occurrence of one stock component in the whole northern area on the shelf area.

Norway pout in the eastern Skagerrak is only to a very small degree a self-contained stock and adults migrate out of the Skagerrak and the Kattegat to spawn, because there is no evidence of spawning there (Poulsen 1968). The main bulk drifts as larvae south-east-wards from more western areas to which they return mainly during the latter part of their second year of life before becoming mature (Poulsen 1968; Lambert et al. 2009; Nash et al. 2012).

Also, the conclusion on one stock component is supported by the depth distribution limits of the species (Poulsen 1968; Albert 1994; Sparholt *et al.*, 2002b; Lambert et al. 2009; Nielsen et al. 2012), i.e. there is no indication that the species migrate outside the shelf areas into deeper waters than 200 m depth. For the Norwegian Trench Albert (1994) found Norway pout deeper than 200 m, but very few deeper than 300 m. However, very few Norway pout are caught at depths greater than 200 m in the North Sea and Skagerrak on shrimp trawl survey (Sparholt *et al*. 2002b).

5. Mortality life history aspects (in relation to growth and maturity)

Norway pout is a small, short-lived gadoid species, which rarely gets older than 5 years (Nielsen, Lambert, Bastardie, Sparholt and Vinther, 2012; Lambert, Nielsen, Larsen and Sparholt, 2009). The mortality patterns of Norway pout (NP) are not well understood. It is most likely a one-time spawner with high spawning mortality (Nielsen et al. 2012). The population dynamics of Norway pout in the North Sea and Skagerrak are very dependent on changes caused by recruitment variation and variation in predation (or other natural) mortality, and less by the fishery. Norway pout is only to a very limited extent exploited from age 0. On this basis Norway pout should be managed as a short-lived species.

Nielsen et al. (2012) suggested that NP undergo heavy spawning mortality. The very low–absent fishing activity in the recent years provided a unique opportunity to analyse the natural life-history traits of cohorts in the NP stock in the North Sea (Nielsen et al. 2012). Based on the ICES trawl survey abundance indices, cohort mortality was found to significantly increase with age. The authors argued that this cannot be explained by selectiveness in the fishery, potential size-specific migrations out of the area, higher predation pressure on older individuals, or differences in survey catchability by NP age from before to after spawning and that it is higher in the main spawning areas than outside. They found that natural mortality (M) is significantly correlated with sexual maturity, sex, growth, and intraspecific stock density. All of this is consistent with a greater mortality occurring mainly from the first to the second quarter of the year, i.e. spawning mortality, which is discussed as being a major direct and indirect cause of stock mortality (**Table 1**; **Figure 23**; **Figure 24**; **Figure 25**).

Table 1. Total mortality (Z) calculated based on IBTS cpue data according to ICES standard calculation procedures and according to the revised calculation procedure (Nielsen et al. 2012; Lambert et al. 2009).

Cohort	Z_{1-2} ICES	Z_{1-2} (revised)	Z_{2-3} ICES	Z_{2-3} (revised)
1981	–	–	2.07	2.52
1982	0.83	0.84	2.60	2.56
1983	1.25	1.23	4.27	4.08
1984	1.81	1.74	1.84	1.91
1985	1.46	1.37	3.47	3.56
1986	1.48	1.38	1.43	1.58
1987	−0.72	−0.55	1.88	1.89
1988	0.99	1.03	1.75	1.35
1989	0.60	0.52	3.10	3.14
1990	1.02	0.96	1.23	1.26
1991	0.65	0.67	3.69	3.60
1992	1.97	1.89	1.58	1.53
1993	0.85	0.85	1.24	1.31
1994	0.81	0.84	1.37	1.44
1995	−0.47	0.26	1.72	1.75
1996	0.60	0.66	2.08	2.08
1997	0.53	0.60	2.22	2.14
1998	0.83	0.71	1.88	1.91
1999	1.04	1.02	1.18	1.18
2000	0.48	0.64	2.15	2.10
2001	1.14	1.00	2.83	2.81
2002	1.19	0.96	2.32	2.47
2003	1.92	1.79	1.58	1.81
2004	1.55	1.59	–	–

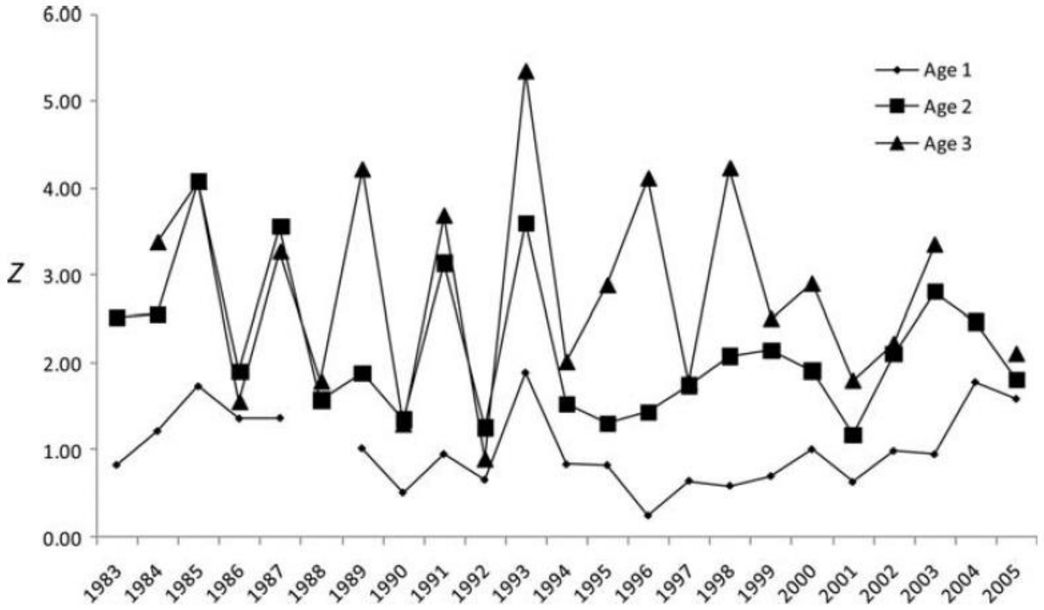


Figure 23. Total mortality (Z) by age over a 23-year period calculated according to Equation (1) based on revised IBTS Q1 cpue data in Nielsen et al. 2012. The negative value from 1988 age 1 was omitted from the calculation. (From Nielsen et al. 2012).

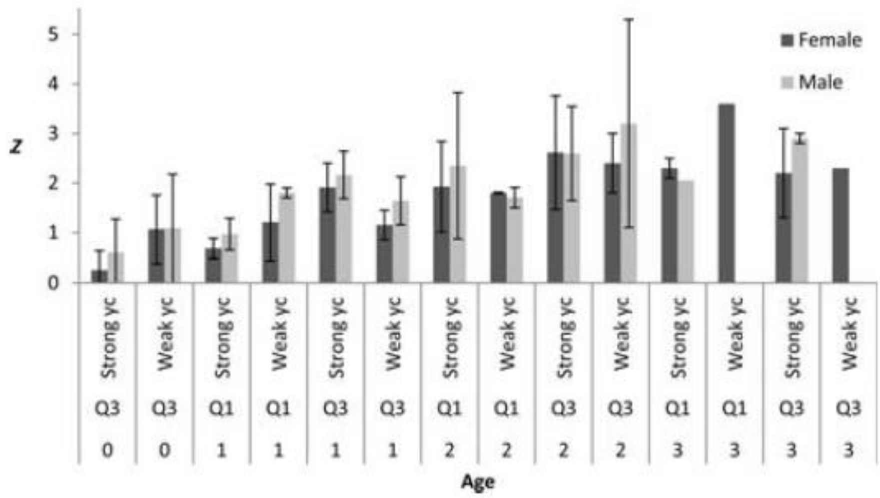


Figure 24. Seasonal total mortalities (Z) by sex and age for strong and weak year classes based on revised IBTS Q1 and Q3 cpue data. Z is calculated according to Equation (1) in Nielsen et al. (2012). Error bars represent the standard deviations. (From Nielsen et al. 2012).

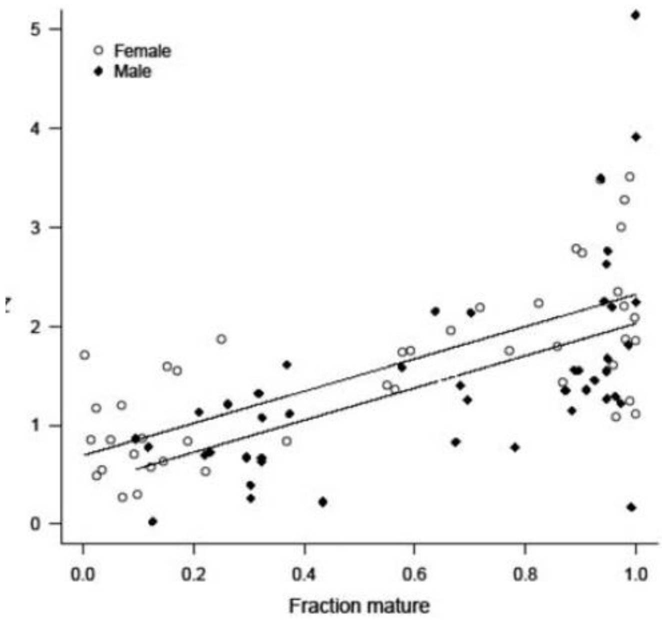


Figure 25. Total mortality (Z) of females (black dots) and males (white dots) as a function of the fraction mature for age groups 1 and 2. Z is calculated according to Equation (1) and based on the revised IBTS cpue data. Regression t-test statistics: $p < 0.001$ for females and $p=0.058$ for males. (From Nielsen et al. 2012).

Nielsen et al. (2012) found that the ratio of mature individuals declined significantly from before to after spawning, and only very few post-spawning Norway pout have ever been observed despite extensive surveying and fishing in the North Sea. For the youngest age classes, the proportion of mature individuals was higher for males than for females, and total male mortality is higher. This is in accordance with Cooper (1983), who found an increasing numerical dominance of Norway pout females with age. Maturity and growth dynamics (Lambert et al. 2009) strongly indicate greater mortality in the spawning areas and during the spawning season.

Geographical maturity patterns showed a significantly higher percentage of mature individuals in spawning areas RFA1 and RFA3, in which there were significant decreases in the maturity ratio from Q1 to Q3, and where more than 90% of the spawners were recorded in Q1 (Nielsen et al. 2012; and Figures 2 and 3 and Table 3 in Lambert et al., 2009). This indicates that the larger, more mature individuals disappear after spawning. It was also observed that total mortality was significantly correlated with the percentage of mature fish (Nielsen et al. 2012). Mortality cannot be directly calculated in the spawning areas during and just after the spawning period, but the results showed that the yearly total mortality for both sexes was significantly positively correlated with the overall maturity ratio assessed during the spawning season (Nielsen et al. 2012). Also, this indicated a higher natural mortality associated with spawning.

The IBPNorwayPout revisions of natural mortality, weight, and maturity parameters at age included in the assessment

The ICES inter-benchmark assessment in spring 2012 (IBPNorwayPout, ICES 2012c) introduced revised estimates of maturity and natural mortality at age used in the Norway pout stock assessment. The background and rationale behind the revision of the natural mortality and maturity parameters is described in the IBPNorwayPout report (ICES, 2012c) and primary literature (e.g. Nielsen *et al.*, 2012; Lambert *et al.*, 2009; ICES WGSAM 2011), as well as summarised below.

Instead of using a constant natural mortality set to 0.4 for all age groups in all seasons as used in the previous assessments then variable natural mortality between ages have been introduced in the 2012 Inter-benchmark assessment and used in all following assessments. The revision of the natural mortality parameter was based on results in Nielsen *et al.* (2012) and the ICES WGSAM 2011 multi-species assessment report. It should be noted that natural mortality levels by age and season used in the stock assessment reflect the predation mortality levels estimated for this stock in the multispecies stock assessment performed by ICES. The revised values are shown in **Table 2**.

Table 2. Norway pout IV & IIIaN (Skagerrak). Mean weight at age in the stock, proportion mature and natural mortality used in the assessment from 2012 onwards. (Inter-Benchmark 2012 assessment scenario 2 settings).

Age	Weight (g)				Proportion mature	M
	Q1	Q2	Q3	Q4		Quarterly
0	-	-	4	6	0	0,29
1	9	14	28	28	0,2	0,29
2	26	25	38	40	1	0,39
3	43	38	51	58	1	0,44

Evaluations performed in the IBPNorway pout

The ICES IBPNorwayPout inter-benchmark exercise evaluated alternative biological inputs in the stock assessment for natural mortality, sexual maturity and growth (mean weight at age in the stock) for the Norway pout stock in the North Sea and Skagerrak. The natural mortality, maturity, and mean weight used in the scenarios evaluated in the benchmarking process originate from results published in Nielsen *et al*. (2012), Lambert *et al*. (2009), Sparholt *et al.* (2002a,b), as well as from the multi-species assessment working group ICES WGSAM 2011. In particular, natural mortality estimates for Norway pout originating from the key run of the multi-species SMS model (2011) were applied. Five scenarios were considered, a Baseline Scenario following the current assessment approach and four additional scenarios which explored alternative biological inputs as presented in **Table 3** and summarized below.

Baseline:

The May 2011 Norway pout assessment was selected as the Baseline assessment. The settings of the Baseline were constant natural mortality by quarter and age fixed at 0.4, 10% maturity for the 1-group and 100 % mature for the 2+ group, and constant MWA assumed in stock. The following alternative scenarios were tested in the benchmark exercise:

Scenario1:

Natural mortality (M) change: Average Z at age used as a proxy for M, computed for ages 1-3 in the years 2004, 2005, 2007 and 2008 (years with low fishing mortality) based on Q1 IBTS ICES NP indices from the standard ICES NP index area (calculated from Q1-Q1 cohorts as averages for these 4 years based on the approach in Nielsen *et al.* (2012, Fig. 1). Yearly Ms were divided by 4 to obtain quarterly Ms, and M at age 0 was set equal to that for age 1. In Scenario 1 the same maturity ogive and mean weight at age was used as in the Baseline assessment.

Scenario 2:

Natural mortality (M) change*:* Same M inputs as Scenario 1. Maturity ogive change: Maturity at age 1 was set to 0.2 from Lambert *et al.* 2009, Fig. 4. Maturity at age 2 was set to 100 %. Mean weight at age in stock (MWA) change: The settings were based on results from commercial fishery during the period

1983 to 2006 as presented in Lambert *et al.* (2009, Fig. 8.). The long term trends in MWA were calculated for the period 1983 to 2011 by quarter and area for the Danish commercial fishery and compared to Lambert *et al.* (2009) Fig. 8 values and were found to be consistent. The revised Mean Weight at Age (MWA) in the stock used in the benchmark assessment were for the 1-, 2- and 3- groups taken as the long term averages from the commercial data. Data for MWA by quarter for age 0 were kept constant as used in the Baseline. MWA was recorded from commercial fishery catch data, but not during the IBTS, from which only length data are available.

Scenario 3:
Natural mortality (M) change*:* Average Z at age (being a proxy for M) for ages 1-3 for the full year range 1983-2005 from Q1-Q1 IBTS revised indices from Nielsen *et al.* (2012) Figure 1 (as presented in **Table 3**). Yearly Ms divided by 4 to obtain average quarterly M's. M at age 0 set equal to that for age 1. Maturity ogive change and mean weight at age (MWA) change: Same as in Scenario 2.

Scenario 4:
Natural mortality (M) change*:* M1+M2 from the multi-species SMS model from 2011 key run presented in the ICES WGSAM 2011 Report. Averages of the SMS estimates of quarterly M1+M2 have been used for the full year range used in the SMS key run (2011). Maturity ogive change and mean weight at age (MWA) change: Same as in Scenario 2.

Table 3. Norway pout IV & IIIaN (Skagerrak). Mean weight at age in the stock, proportion mature and natural mortality used in the assessment. Baseline settings and Scenario 1-4 settings for population dynamics parameters. New parameter settings are in red.

Baseline

Age	Weight (g) Q1	Q2	Q3	Q4	Proportion mature	M Quarterly	M values evaluated (Exploratory run)
0	-	-	4	6	0	0.4	0.25
1	7	15	25	23	0.1	0.4	0.25
2	22	34	43	42	1	0.4	0.55
3	40	50	60	58	1	0.4	0.75

Scenario 1

Age	Weight (g) Q1	Q2	Q3	Q4	Proportion mature	M Quarterly
0	-	-	4	6	0	0.29
1	7	15	25	23	0.1	0.29
2	22	34	43	42	1	0.39
3	40	50	60	58	1	0.44

Scenario 2

Age	Weight (g) Q1	Q2	Q3	Q4	Proportion mature	M Quarterly
0	-	-	4	6	0	0.29
1	9	14	28	28	0.2	0.29
2	26	25	38	40	1	0.39
3	43	38	51	58	1	0.44

Scenario 3

Age	Weight (g) Q1	Q2	Q3	Q4	Proportion mature	M Quarterly
0	-	-	4	6	0	0.26
1	9	14	28	28	0.2	0.26
2	26	25	38	40	1	0.54
3	43	38	51	58	1	0.71

Scenario 4

Age	Weight (g) Q1	Q2	Q3	Q4	Proportion mature	M Quarterly
0	-	-	4	6	0	0.65
1	9	14	28	28	0.2	0.41
2	26	25	38	40	1	0.35
3	43	38	51	58	1	0.29

Results of the evaluations performed in the IBPNorway pout

The change in natural mortality in Scenario 1, where survey based average Zs in the 4 years with very low or no fishing mortality has been used as a proxy for M, resulted in applying M-values of similar magnitude by age and quarter (around 0.3 for age 0 and 1 and 0.4 for age 2 and 3) as the age and quarter invariant values used in the Baseline assessment (0.4 by age and quarter). The total mortality on the cohort (and the age specific variation herein) determines the recruitment, the number of survivors and the biomass. The slightly lower natural mortality for the 0-group fish, for which the fishing mortality was very low, and the slightly higher natural mortality for the oldest fish (age 3 at 0.44) resulted in a slightly lower total stock biomass (TSB) and R and nearly the same SSB and Fbar(1-2) as the Baseline. This was expected given these modest age specific changes in M between Baseline and Scenario 1. The maturity ogive in Scenario 1 was the same as the Baseline with only 10% of age 1 mature, resulting in SSB similar to the Baseline. Because the catch at age data used in the Baseline and in all tested scenarios was the same, and because natural mortality on the main fished part of the population, i.e. age 1-3, was slightly lower for age 1 at 0.29 and slightly higher for age 3 at 0.44 in Scenario 1 (and 2)), this resulted in the recruitment being a little bit lower while fishing mortality was similar comparing Scenario 1 (and Scenario 2) with the Baseline. The same perception of the stock dynamics (fluctuations) over time was observed for Scenario 1 and the Baseline.

Scenario 2 had the same natural mortality change used as in Scenario 1 but the maturity ogive and MWA vector were different. The maturity ogive was changed to 20% mature of the 1-group, and the revised MWA in the stock was applied, obtained from long term averages measured from the commercial fishery catch. The changes in MWA were minor compared to the Baseline and did not have much impact. The change in the maturity ogive, where 20% are mature compared to value of 10% in the Baseline resulted in a higher SSB in Scenario 2 compared to the Baseline (and Scenario 1) as would be expected. The same trends in R and TSB as well as F were observed in Scenario 2 as in Scenario 1 and the reason for this was the same as described above under Scenario 1. Also recruitment was somewhat lower under Scenario 2. In combination, higher SSB and lower R under Scenario 2 implied a lower overall recruitment rate (R/SSB). Overall, the same perception of the stock dynamics (fluctuations) over time was observed for Scenario 2 and the Baseline.

Scenario 3 operated with bigger changes in mortality by age compared to the baseline. In this scenario the M-value for the 0- and 1-groups was around 0.25 and the M for the older age groups were significantly higher (around 0.55 for age 2 and 0.7 for age 3). The same maturity ogive and MWA vector was in Scenario 3 as was used in Scenario 2. Much higher mortality on the old, large fish together with fishing mortality resulted in a high total mortality on the older fish, and consequently, there needed to be more recruits to sustain this mortality (as the same number of fish was caught in all scenarios). This resulted in higher R, and a much higher TSB and SSB, and a perceived lower fishing mortality. Because of the significant change in M in this scenario the stock dynamics and perception of the stock and recruitment for Scenario 3 were different over time compared to the Baseline.

Scenario 4 used the multi-species model estimates of M where the quarterly mortality was higher on the young fish and lower on the older fish, i.e. around 0.65 for age 0, 0.4 for age 1, 0.35 for age 3 and 0.3 for age 3. This resulted in similar TSB and SSB as the Baseline but a perception of slightly higher recruitment and fishing mortality.

Conclusions on the evaluations performed in the IBPNorway pout

The independent reviewers considered that the new values for biological inputs constituted an improvement to the assessment of Norway pout and they supported the use of Scenario 2 as the new Baseline for the stock assessment. They expressed some concern regarding the estimation of mortality rates from survey data without accounting for the survey catchability at age. Ideally natural mortality should be estimated within the stock assessment model simultaneously with estimates of survey catchability, but in most cases the data are inadequate to do this. Evidence of density dependence in Norway Pout mortality, growth and maturation rates suggested that using fixed estimates in stock assessments could lead to biases and this was worthy of further investigation. The reviewers noted that the stock-recruit scatter was relatively uninformative but considered that the values being used for biological reference point should still apply. Consideration could also be given to a higher target escapement level given the importance of Norway Pout as a forage species in the ecosystem.

The Benchmark group concluded that revisions to natural mortality, maturity and mean weight at age should be included in the final benchmark assessment based on the approach in Lambert *et al*. (2009) and Nielsen *et al.* (2012). It was not recommended that Z values be used as proxies for M values for the full year range since 1983 (Scenario 3) as this average included fishing mortality which, especially in the early part of the period, was relatively high, i.e. this gave a biased over-estimation of M. Both Scenarios

2 and 4 were found worthy of further consideration in the Benchmark. The results of Scenarios 2 and 4 were not significantly different from the baseline scenario, and both scenarios gave the same perception of the stock dynamics (fluctuations) over time was observed for the baseline.

The population dynamic parameters and approach used in Scenario 2 have been documented in Nielsen *et al*. (2012) and in Lambert *et al*. (2009). SMS estimates of mortality on A1 were higher than those based on Z estimates from the IBTS index. This difference in perception could occur if the catchability on A1 was low. The above cited papers investigate and argue that the catchability of the 1-group Norway pout was not lower than for the older age groups (although this was somewhat contrary to the catchability estimates at age for IBTS coming out of both the Baseline and the Scenario 2 SXSA assessment model estimates), and that there was no age specific migration out of the assessment area (being the whole North Sea and Skagerrak-Kattegat).

Scenario 4 used results of M from the SMS model assessment which had a number of characteristics and assumptions as well. The SMS assumed constant residual mortality at age (M1), i.e. natural mortality due to other reasons than predation. This was in contradiction to potential spawning mortality as discussed in Nielsen *et al.* (2012) which would result in M increasing with age. Also, the SMS smoothed mortality out between ages 1-3, i.e. did not fully consider potential differences in natural mortality between these ages, because the model used rather wide size intervals in its prey-predator preference model (ICES 2011b; Pers. Comm. Morten Vinther and Anna Rindorf, DTU Aqua, March 2012). This meant that the mortalities between age 1, age 2 and age 3 tended to be equalized in the model. In the SMS a main predator on Norway pout age 1 to age 3 was saithe, and the SMS assessment results are sensitive to biomass estimates of saithe in the North Sea. The SMS used the saithe (predator) biomass estimates from the ICES WGNSSK single stock assessment (ICES WGNSSK 2011), and this assessment was very uncertain. Consequently, the SMS natural mortality estimates on Norway pout were dependent on uncertain assessment estimates of saithe in the North Sea which also influenced age specific mortalities on Norway pout. In comparison with the analysis of IBTS survey data, SMS estimates of total yearly M (and also Z) were higher for age 0 and 1 and lower for age 2 and 3 Norway pout (Nielsen *et al.* 2012). Even if the catchability in the surveys was lower for age group 1 then it was difficult to explain the lower mortalities estimated by the SMS for age 2 and age 3 compared to the observed age 2 and age 3 survey based mortality estimates. In Nielsen *et al.* (2012) it was argued that migration in or out of the area was very unlikely, so the lower estimates of Z from SMS at age 2 and especially age 3 compared to estimates from the the IBTS data (Nielsen *et al.* 2012) was difficult to explain.

In conclusion the benchmark group agreed that Scenario 2 was preferred based on the available information, and recommends Scenario 2 be used as the new baseline assessment for the Norway Pout stock from 2012 onwards.

Natural mortalities from multi-species assessments

In **Figure 26** below the total mortality (Z) and natural predation mortality (M2) of Norway pout by age for the period 1983-2013 is shown as estimated by the SMS model in the 2013 baseline run. The yearly values are shown, but the SMS does also estimate quarterly mortalities. The natural mortalities, M, from the SMS run is variable by year and quarter. If the variable natural mortality values from SMS are used in the Norway pout assessment the following points should be taken into consideration:

a) The SMS does not take into account likely spawning mortality (see also the 2012 inter-benchmark conclusions above).
b) The natural mortalities of Norway pout from SMS area very dependent on uncertain predator assessment biomasses (both from single species assessments and multi-species assessments), especially for saithe, but also for western Mackerel (see also the 2012 inter-

benchmark conclusions above). Furthermore, the migration patterns (and extension of distribution) of western mackerel into the North Sea is very variable between years and over the whole period, and this is not well estimated.

c) The SMS is not up-dated every year and the last SMS key run is for 2013. Accordingly, M values for Norway pout need to be assumed or taken as constant mean averages anyway in the last 3 terminal assessment years (2014-2016). Accordingly, we will not have yearly and quarterly variable values available anyway from SMS on M to include into the SXSA for the latest 3 years which are the most important years in assessment and forecast context. The SMS key runs are made every third to fourth year, and the experience is that the M values changes drastically every time a key run is made (e.g. from the 2011 key run to the 2013 key run). This means that we have to assume the M values anyway for the recent and most important years in the assessment anyway (as it is only 3 age classes that are important in the assessment), and that the M values will change every time a new SMS key run is made.

d) If we change the absolute biomass / abundance of Norway pout in the single stock benchmark assessment significantly then the M values for Norway pout in the SMS are "not correct" as the SMS estimates and assessment of Norway pout biomass is adjusted to fit the single stock assessment biomass ("fiddled to match the single stock assessment").

In general, the SMS estimates the natural mortality higher for 0- and 1-group Norway pout compared to the estimates for the same age groups in Nielsen et al. (2012). However, this is not the case in the period 1990-2000 where the estimates of M for age 0 and 1 are at the same level in the SMS and in Nielsen et al. (2012). The natural mortality is lower in the SMS for age 2 and 3 compared to the estimates for the same age groups in Nielsen et al. (2012). This difference is due to the SMS do not take into account potential spawning mortality increasing the M with age as estimated in Nielsen et al. (2012).

In the Ecopath w. Ecosim Model (EwE) the total mortality and the predation mortality (M2) for Norway pout is not estimated by age group but combined for all age groups (and combined for juvenile and adult) of Norway pout. In **Figure 27** below the yearly total mortality (Z) and the yearly predation mortality (M2) from the EwE is shown for the period 1991 to 2013 based on the latest EwE key run in 2015. The values are total for all age groups and both juveniles and adults of Norway pout.

The EwE estimates the predation mortality rather high in the start of the period from 1991-2013 at levels around 2, but with a decreasing tendency over time to a level around 1.5 in the end of the period. The latter level is in accordance with the general level of M2 in the SMS and in Nielsen et al. (2012).

Many of the above aspects mentioned in relation to the SMS is also the case with respect to EwE estimates of natural mortality (predation mortality) for Norway pout.

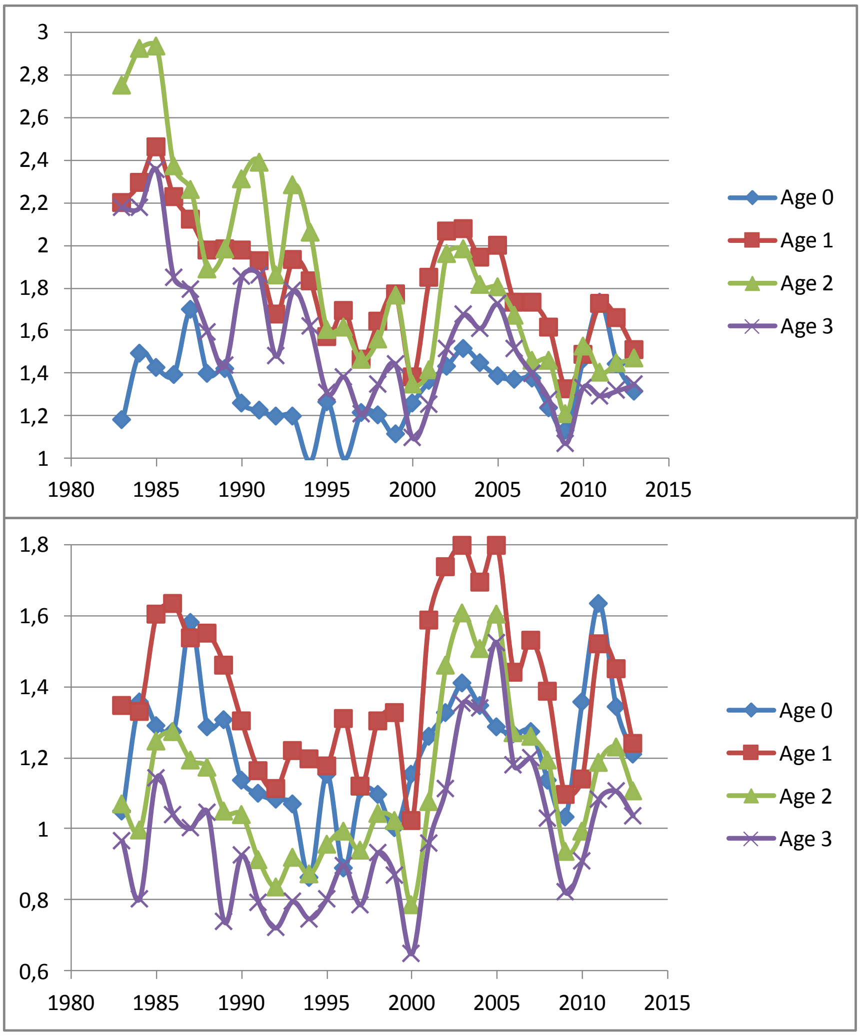


Figure 26. Total mortality (Z) and natural predation mortality (M2) of Norway pout by age for the period 1983-2013 as estimated by the SMS in the 2013 baseline run.

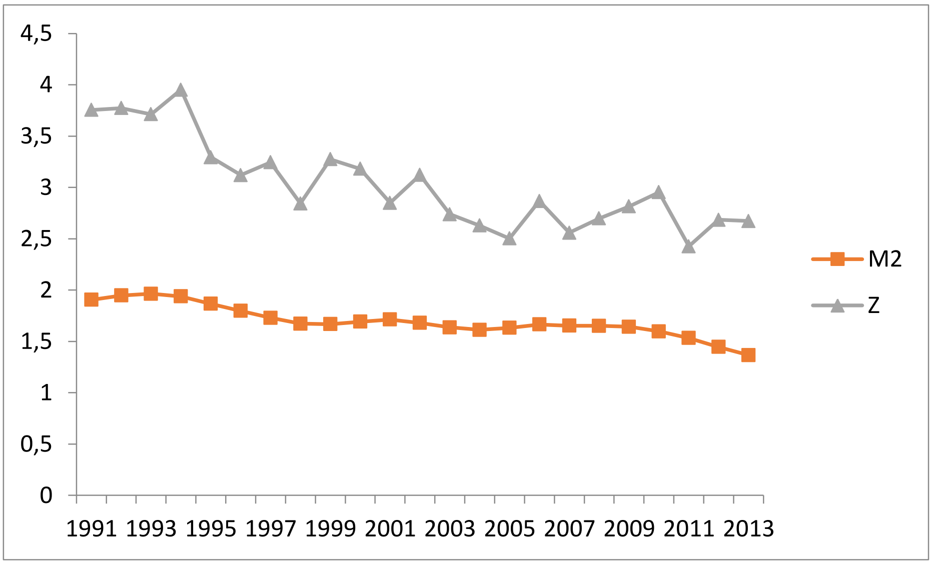


Figure 27. Total mortality (Z) and natural predation mortality (M2) of Norway pout by age for the period 1991-2013 as estimated by the EwE in the 2015 baseline run.

Previous benchmark analyses of natural mortality

Possible revision of the natural mortality parameter in the assessment was also evaluated in the September 2006 benchmark assessment in response to the wish from ACFM RG 2006 on a separate description of natural mortality aspects for Norway pout in the North Sea. In summary no conclusions could be reached from the exploratory runs then using different natural mortalities from previous primary literature (Sparholt *et al*., 2002a,b; ICES 2006) as the mortality between age groups was contradictive and inconclusive between periods (variable) from the different sources used showing different trends with no obvious biological explanation. On that basis it was in the 2006 benchmark assessment decided that the final assessment continues using the constant values for natural mortality at age. The background for these conclusions and the benchmarking in 2006 was that exploratory runs of the SXSA model was presented in the 2001 and 2002 assessment reports as well as in the 2004 and 2006 assessments (Norway pout benchmark assessments) with revised input data for natural mortality by age based on the results from two papers presented to the working group in 2001, (later published in Sparholt et al., 2002a,b) as well as natural mortality estimates from the North Sea MSVPA model (ICES SGMSNS 2006) in the 2006 assessment (ICES CM 2006/ACFM:35). These revised natural mortalities were given in the 2004 ICES WGNSSK Report (ICES WGNSSK (2005); ICES CM2005/ACFM:07) and the ICES WGNSSK 2006 report including the described inter-benchmark assessments. Furthermore, estimates of total mortality based on the SURBA assessment model estimates (2005 SURBA run for Norway pout, ICES C.M. 2006/ACFM:35) using all survey time series included in the baseline assessment (ICES CM 2007/ACFM:18 and 30) covering the period 1983-2005 indicated that for the period up to 1990-1995 the Z estimated from SURBA and Sparholt *et al*., 2002a,b wass at the same level for both the 1-2 group and 2-3 group, and there also seems to be age specific differences in Z. In the period from 1995 and onwards the Z-estimates from SURBA were lower compared to the constant M values obtained from Sparholt *et al*., 2002a,b. In later years from 2002-03, the SURBA estimates of Z increased again compared to the period 1995-2001. In conclusion, the exploratory runs gave very much similar results and showed no differences in the perception of the stock status and dynamics. Previous evaluation of total mortality Z, in years where fishing mortality has been very low and where total mortality accordingly approximately equals natural mortality, was conducted and presented in the September 2007 WGNSSK Report (ICES CM 2007/ACFM:18 and 30, **Table** 5.2.12). This evaluation was based on catch curve analysis on recent (IBTS Q1 and Q3) survey estimates for Norway pout. The results indicated somewhat different levels of Z between different survey time series mirroring the results from the 2006 benchmark assessment.

6. Biological interactions

Norway pout natural mortality is likely influenced by spawning and maturity having implications for its age specific availability to predators in the ecosystem and to the fishery (Nielsen *et al*., 2012).

In previous ICES stock assessments it has under ecosystem consideration been noted that there is a need to ensure that the Norway pout stock remains high enough to provide food for a variety of predator species (e.g. ICES WGNSSK 2011a). This stock is among other important as food source for the species saithe, haddock, cod, whiting, and W. mackerel and predation mortality is significant (ICES-WGSAM 2014 with most recent 2013 SMS Key Run; ICES-WGSAM 2011, ICES-SGMSNS 2006). Especially the more recent high abundance of saithe predators and the more constant high stock level of western mackerel as likely predators on smaller Norway pout in the North Sea are likely to significantly affect the Norway pout population dynamics.

The ICES inter-benchmark assessment in spring 2012 (IBPNorwayPout, ICES 2012c) evaluated multispecies considerations in relation to the natural mortality population dynamics parameters in the benchmarking for Norway pout stock in the North Sea and Skagerrak including predation mortality. In the 2012 inter-benchmark a series of assessment scenarios were run with different parameter settings of natural mortality. Natural mortality has been derived from analysis of total mortality rates estimated from IBTS survey catchrates (cpue from IBTS Q1 and Q3) using the approach described in Nielsen et al. (2012); Lambert et al. (2009) and Sparholt et al. (2002a,b). Furthermore, natural mortalities derived from the multispecies SMS model from the 2011 SMS key run were used in one of the exploratory scenarios (Scenario 4) in the benchmarking. This is described under natural mortality in Section 3.6.4 of the IBPNorwayPout report (ICES 2012c).

The 2012 inter-benchmark introduce revised estimates of maturity and natural mortality and maturity at age used in the Norway pout stock assessment. The background and rationale behind the revision of the natural mortality and maturity parameters is described in the IBPNorwayPout report (ICES, 2012c) and primary literature (e.g. Nielsen et al., 2012; Lambert et al., 2009; ICES WGSAM 2011)). A follow up on this analysis is presented in Nielsen (2016; Appendix 1, Section 3) with the same conclusions.

The inter-benchmark (IBPNorwayPout, ICES 2012c) group did not recommend revised reference points for the stock at this stage, but concluded that higher escapement targets could be considered in the future based on the importance of Norway pout as a forage species in the ecosystem. The consumption amount of Norway pout by its main predators should be evaluated in relation to production amount in the Norway pout stock under consideration of consumption and production of other prey species for those predators in the North Sea ecosystem. There most likely is difference in preference and switching between prey species and size groups by different predator species, and in different areas and seasons having different communities and food webs. Those factors and their variability needs to be taken into account when trying to establish target reference levels for Norway pout based on estimating necessary Norway pout biomass to be available for predators in the North Sea and Skagerrak. This should be considered for all prey species together for those predators and not only for Norway pout isolated.

The WGNSSK Assessment Review Group (WGNSSK 2007) asked the WG to provide guidance on how to deal with the objective of keeping a certain amount of biomass for predators. Here it was noted that if a minimum biomass is found to be required, then natural mortality could not be kept constant in the prediction (as it does during the assessment period).

It should be noted that natural mortality levels by age and season used in the stock assessment reflect the predation mortality levels estimated for this stock in the most recent multispecies stock assessment performed by ICES. Natural mortality levels by age and season used in the stock assessment do include the predation mortality levels estimated for this stock (ICES-WGSAM 2014; ICES-WGSAM 2011; ICES-SGMSNS 2006), and in the 2012 Inter-benchmark assessment revised values for natural mortality have been used which also include the estimated levels of predation mortality in the 2011 and 2013 SMS key/baseline run multi-species assessments (ICES-WGSAM 2011; 2014).

Intraspecific dynamics

Interspecific and intraspecific density patterns in Norway pout mortality has been documented (e.g. Nielsen *et al*., 2012; Nash et al. 2012; Lambert et al. 2009; Kempf et al. 2009; Cormon et al. 2016).

Concerning intraspecific interactions and potential density dependency then the juvenile growth rate is higher when the stock density is low (**Figures 13-14**) and results in a reduced age-at-50%-maturity (**Figures 15-17**; Lambert et al. 2009). The study by Lambert et al. (2009) showed only weak intraspecific density-dependence in growth and maturity, as well as in age and length at maturity, but the general trend found was that both these parameters decreased with the number of fish in a cohort. Although these correlations could highlight a phenomenon of density-dependence linked to local aggregation (as for herring; Engelhard and Heino, 2004) or food availability, perhaps the reductions can be explained by density- and size-dependent juvenile mortality (Lambert et al. 2009).

Nielsen et al. (2012) found that natural mortality (M) is significantly correlated with sexual maturity, sex, growth, and intraspecific stock density. According to Nielsen et al. (2012) the density dependence, either intra- or interspecific, of NP mortality showed a distinct pattern. They found that mortality was significantly positively correlated with intraspecific population density (**Figure 28**). The NP population dynamics seemed, therefore, to be influenced by density-dependence, which resulted in a lower growth rate and maturation when the stock was at a relatively high level. Thus, bringing together the varied information pertaining to NP mortality, it is likely that lower stock densities contribute to higher growth rates and higher maturity ratios and, consequently, greater mortality rates, which are most likely caused by spawning. Kempf et al. (2009) found no intraspecific relationship between NP SSB in the year of birth and the IBTS age 1 recruitment index of the following year, whereas the inter-annual variability in age 1 recruitment was found to be correlated with the Q2 sea surface temperature when taking predation impact into consideration. However, this was not highly significant and included the removal of years characterized as outliers. Although the analyses of Nielsen et al. (2012) indicated density-dependent mortality which could be associated with spawning and that available documentation on predation could not explain the observed increase in Z at age, it was difficult to disentangle density-dependent mortality and size-selective mortality (Nielsen et al. 2012). Size-selective mortality will usually result in greater mortality of the smallest (youngest) fish, but for Norway pout, greater mortality rates for the largest (oldest) fish were observed, and that spawning was not only associated with age, but also with size. Nielsen et al. (2012) found evidence of spawning mortality where the fastest growing individuals mature faster and therefore spawn and die faster, but also found that there may be other reasons for such reversal size-selective mortality, e.g. density-dependence. They argued that density-dependence probably did not influence mortality directly, but rather indirectly as explained above, and can also be influenced by size-selective mortality other than spawning mortality, so no rigorous conclusions can be made on this.

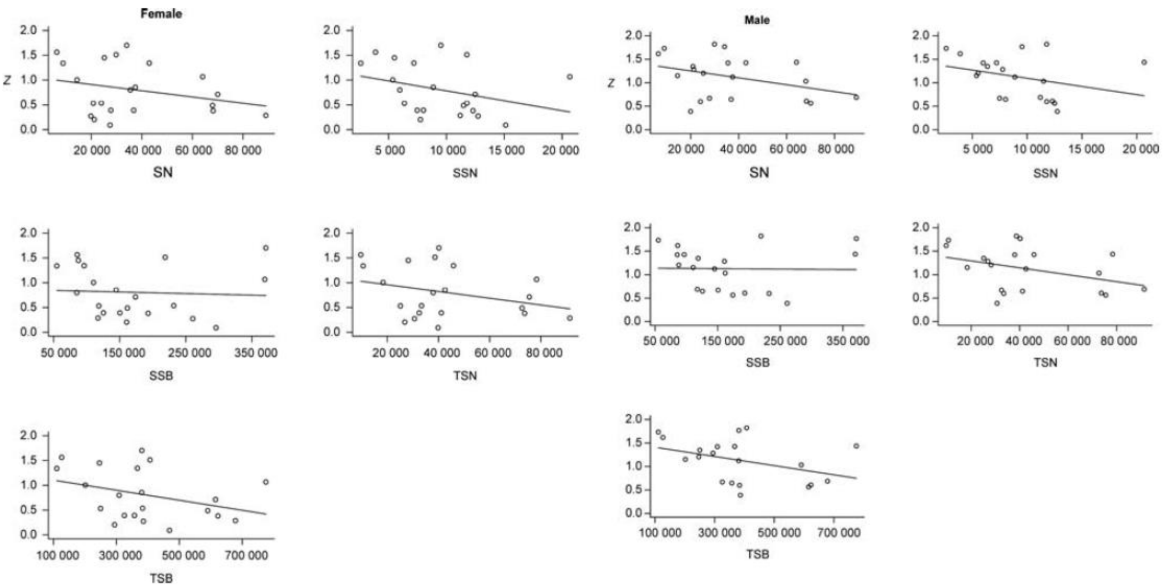


Figure 28. Total mortality (Z) based on revised IBTS Q1 cpue at age 1 vs. NP age 1 stock number (SN; r2f=0.08, p=0.222; r2m=0.14, p=0.106), spawning-stock number (SSN; r2f=0.11, p=0.145; r2m=0.10, p=0.178), SSB (t; r2f=0.00, p=0.807; r2m=0.00, p=0.942), total stock number (TSN; r2f=0.09, p=0.177; r2m=0.15, p=0.096), and total-stock biomass (TSB; t) (r2f=0.12, p=0.117; r2m=0.15, p=0.089). Female figures at left, and male figures at right; regression lines are shown; numbers in millions and biomass in tonnes (t). Z is calculated according to Equation (1). (From Nielsen et al. 2012)

Interspecific dynamics

Besides intraspecific patterns, the growth rates show interspecific links to stock sizes of the important predators: cod, haddock, and whiting (Lambert et al. 2009). Especially interspecific density dependent patterns in Norway pout growth and maturity were found in relation to North Sea cod and whiting stock abundance (Lambert *et al*., 2009). The interspecific density-dependence in growth of Norway pout found by Lambert et al. (2009) revealed a positive correlation between whiting SSB and growth, and a negative one with cod and haddock SSB (**Figure 29**). Cod and haddock being larger species probably target larger prey, whereas whiting likely target smaller Norway pout. However, other factors could influence these observations. Raitt and Adams (1965) compared the feeding habits of Norway pout and whiting and showed an extensive overlap between what 0-group whiting and adult Norway pout were eating. Therefore, even if adult whiting are important predators on small Norway pout (Jones et al., 1954; Daan and Welleman, 1998), the positive correlation between both could be due to simple food availability and the effects of competition for food lowering the MWA for Norway pout and whiting recruits. Depending on the strength of the stock–recruitment relationship for whiting, this could affect the relationship between Norway pout growth and whiting SSB (Lambert et al. 2009).

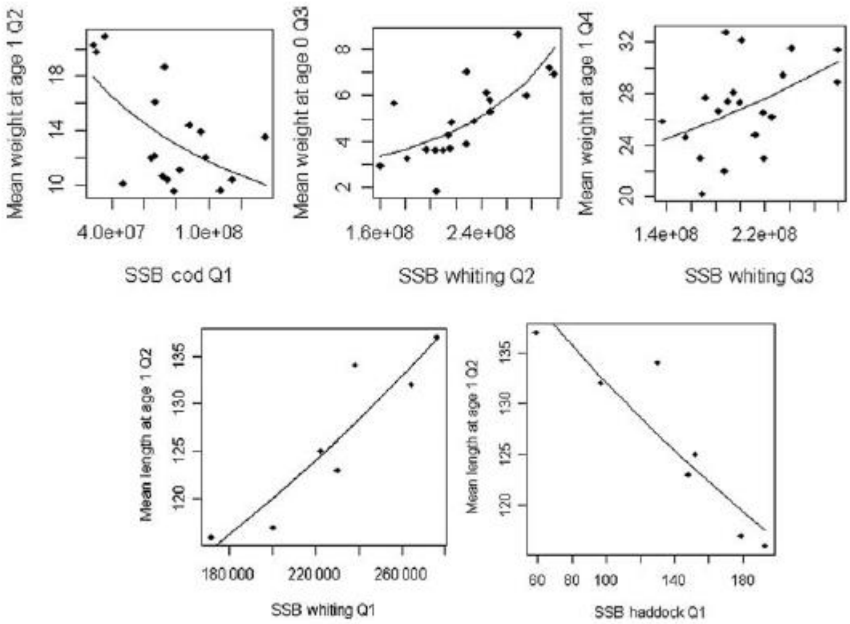


Figure 29. Statistically significant interspecific density-dependence for other species than Norway pout in MWA (top panels) and MLA (bottom panels). (From Lambert et al. 2009).

Interspecific density-dependence and predation were not significant factors influencing Norway pout mortality (**Figure 30**) based on the available data at the scale of the study by Nielsen et al. (2012), and additional studies are necessary on more disaggregated coverage and overlapping distribution and density patterns between Norway pout and its main predators by age or size group, especially during the spawning period (Nielsen et al. 2012). With regard to the overlap between NP and important predators in the North Sea, Rindorf et al. (2010) found low predated biomass and predation mortality in the main spawning areas during the spawning season. Kempf et al. (2009; Figure 10) found no strong correlation between the spatial overlap of NP age 1 abundance and certain NP predators (saithe, haddock, and mackerel) in the IBTS Q3 survey. However, strong predator–prey relationships do exist between some commercially important North Sea stocks and Norway pout (e.g. Cormon et al. 2016; Kempf et al. 2009; Huse et al. 2008). Early studies found that adult whiting is an important predator of small Norway pout (Jones, 1954; Daan and Welleman, 1998).

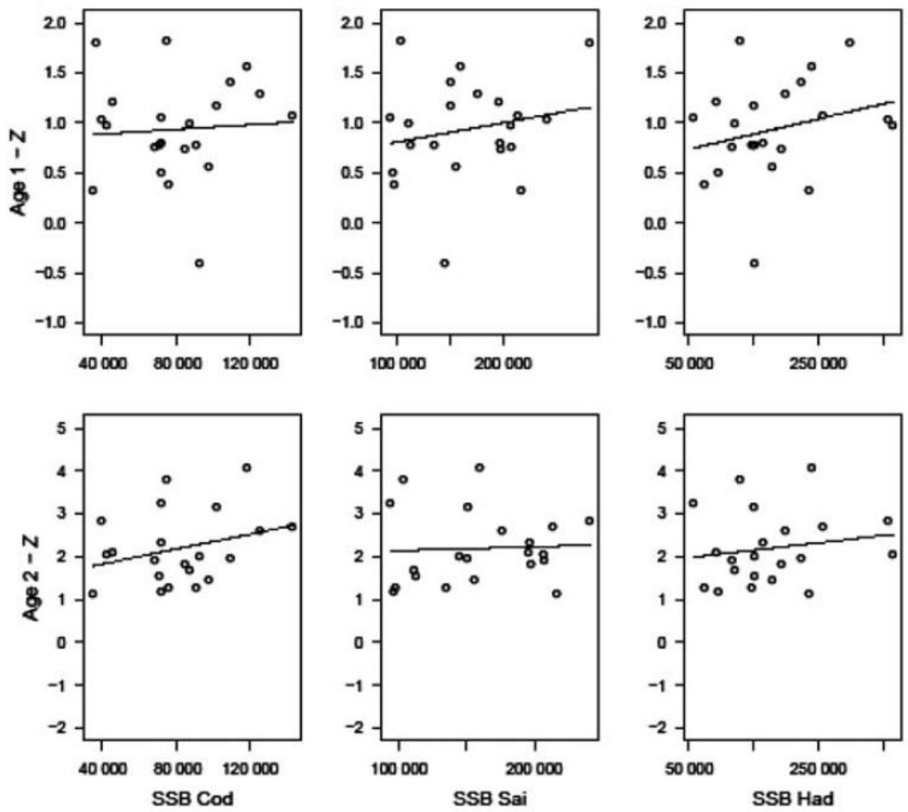


Figure 30. Total mortality (Z) based on revised IBTS Q1 cpue at age 1 (top panels) and age 2 (bottom panels) vs. SSBs (t) of three main predators on 1 January. Regression lines of the relationships shown for cod (Cod; age 1, r2=0; age 2, r2=0.08), saithe (Sai; age 1, r2= 0.04; age 2, r2=0), and haddock (Had; age 1, r2=0.06; age 2, r2=0.03). Z is calculated according to Equation (1). (From Nielsen et al. 2012).

Based on stomach-content data analyses disaggregated to ICES statistical square (area) and quarter of the year in the North Sea (1991), Rindorf et al. (2010) calculated biomass eaten and local predation mortality indices. They found that predated biomass (and predation mortality) of Norway pout by cod, whiting, haddock, and saithe was high in the second half of the year (Q4 and Q3) and low in the first half (Q2 and Q1). In Q1, the small Norway pout biomass eaten occurred in the most northern areas west of Orkney and south of Shetland. Based on Rindorf et al. (2010, Figures 2b and 5b), the areas of highest biomass predated and highest predation mortality were not in the main spawning areas during the spawning season (Q1) that were identified by Lambert et al. (2009, e.g. Figure 1) and Nash et al. (2012) – see **Section 3** – i.e. the areas to be in proximity to the 120-m isobaths in RFA1 and RFA3 near Viking Bank along the Norwegian Trench and along the Scottish east coast (and in RFA7) in Q1. Consequently, predated biomass and predation mortality was low in the main spawning areas and during the spawning season, indicating that increased mortality cannot be explained by predation mortality.

Several hypotheses have been advanced to explain heavy larval mortality (reviewed by Chambers and Trippel, 1997), including predation by planktivorous fish owing to their potentially high densities and efficient foraging on fish larvae. Recruitment of many fish stocks in the North Sea has been exceptionally poor recently (ICES, 2007b –see Huse et al. 2008), and this has led to a re-examination of the hypotheses about different factors affecting fish recruitment (Huse et al. 2008). A negative relationship between pelagic fish abundance and recruitment of demersal fish has been suggested for the North Sea, specifically because the so-called "gadoid outburst" during the 1960s coincided roughly with a collapse in North Sea herring and mackerel stocks (Cushing, 1980; Daan et al., 1985, 1994). However, the timing of various events in the 1950s and 1960s does not fully support a negative relationship between biomass levels of pelagic fish and recruitment of gadoids (Hislop, 1996). On the other hand, the recent poor recruitment to many North Sea stocks has coincided with a large herring stock, which again raises the question of predatory interactions (Huse et al. 2008). Low recruitment of Norway pout could be due to predation by herring, because there is potential for spatial overlap between the two stocks, although there is no information available on stomach content analysis to suggest such an interaction (Huse et al. 2008). Herring (*Clupea harengus*) has been suggested to be a major predator on fish larvae in the North Sea, and Huse et al. (2008) investigated possible interactions between herring and Norway pout using a simple statistical analysis and a modified stock–recruit relationship. They found a significant negative relationship (linear regression) between total herring biomass and recruitment of Norway pout. The spawning stock of Norway pout is typically dominated by 2-year-olds, and there was a strong negative relationship (linear regression) between herring biomass and Norway pout spawning-stock biomass (SSB) 2 years later (Huse et al. 2008). A Beverton–Holt model fitted by Huse et al. (2008) to stock–recruit data of Norway pout produced a rather poor correlation. However, when only the Norway pout SSB not overlapping with herring was considered the fit between the model and the stock–recruit data improved. These analyses indicated a negative impact by herring on recruitment of Norway pout, the most plausible cause for this being herring predation on Norway pout larvae, but field studies are needed to verify such predation (Huse et al. 2008). For herring, the estimated total-stock biomass was taken from the final assessment in the Report of the Herring Assessment Working Group for the Area South of 628N (Huse et al. 2008). For Norway pout, estimates of SSB, recruitment (numbers of fish aged 0 in quarter 3), proportion mature-at-age, mean weights-at-age, and stock numbers-at-age in the North Sea and Skagerrak were taken from ICES (2007c; the working group report that was the basis for the ICES advice in spring 2007). The spatial distributions of herring and Norway pout were estimated based on abundance indices per ICES rectangle, derived from the quarter 1 International Bottom Trawl Survey (IBTS) for the period 1982–2006 (Huse et al. 2008).

According to Cormon et al. (2016) recent assessments of the North Sea saithe *Pollachius virens*, a major top predator in the area, suggested a decrease in spawning stock biomass along with a decline in saithe mean weight-at-ages. In this context, Cormon et al. (2016) investigated North Sea saithe growth characteristics at the population level: First, saithe annual weight increments and age−length relationships were studied. Then, modelling of saithe age−length relationships was carried out using (1) the traditional von Bertalanffy growth function model, (2) the Verhulst logistic model, and (3) an empirical linear model. Second, the effects of environmental factors on saithe growth were investigated. The explanatory environmental factors included in the study was food availability, represented by the total biomass of Norway pout *Trisopterus esmarkii*; intraspecific competition, i.e. density dependence, represented by saithe abundance; and temperature. The study of Cormon et al. (2016) indicated that the Verhulst logistic model was the best descriptor of saithe growth and that density dependence and food availability had significant effects on the saithe growth coefficient, while no effect of temperature was shown. On this basis, the authors suggested that reduced food availability and increased competition may explain the recent decrease in the saithe growth coefficient. It should here be carefully noted that the age length keys of Norway pout survey data from the ICES IBTS surveys used in the study by Cormon et al. (2016) were not scrutinized and analysed on a disaggregated seasonal and area basis as the results from Lambert et al. (2009) revealed were necessary to obtain realistic growth data and parameters for this Norway pout stock.

The interplay between temperature-related processes and predation in determining age-1 recruitment strength between 1992 and 2006 was analysed for North Sea cod (*Gadus morhua*) and Norway pout (*Trisopterus esmarkii*) by Kempf et al. (2009). For this purpose, a predation impact index (PI) was calculated out of IBTS survey data. PI was assumed to depend on the abundance of the predators and on the spatial overlap between predator and prey populations. Generalized additive models (GAMs) were created with spawning stock biomass (SSB) and sea surface temperature (SST) in the respective spawning and nursery areas and PI as explaining variables. Intraspecific SSB had no significant impact on recruitment during this time period for both species. SSTs during spring and PI explained together the interannual variability in recruitment strength to a large extent (88% of the total variance for cod and 68% for Norway pout). The SST during spring determined the overall level of recruitment. At SSTs above a certain level, however, the effect on recruitment was no longer significant. In these temperature ranges, predation was the dominant effect. On this basis, Kempf et al. (2009) stated that the fate of North Sea cod and Norway pout stocks under global-warming conditions will be strongly influenced by the status of the North Sea food web. See more detailed results of this study in **Section 7** on environmental drivers below.

When scrutinizing mean predation mortality (M2) caused by predator species and age groups partly in a table with predation by predator species and age on Norway pout per age group (**Table 4**) and a table with predation by predator species in total per Norway pout age group (**Table 5**), as well as graphs of Norway pout relative importance (share) in diet per predator size group from the SMS 2013 baseline run then it is possible to assess the most important predators by species and age on Norway pout in the North Sea (**Table 6** with examples). All this information is necessary to evaluate the importance of Norway pout in the diet for the different predators and predator age groups as a high M2 can be caused by partly a high proportion of Norway pout in the diet but also by a high predator (by age) biomass / abundance. Therefore, the partiel M2 is not necessarily a good measure for importance of Norway pout in the diet. Accordingly, it is also necessary to analyse graphs of Norway pout relative (share) importance in diet per predator size group.

Table 4. Average (1974-2013) partial predation mortality (M2) from SMS of Norway pout by age group of Norway pout and predator (SMS 2013 baseline run).

Species / Age	0	1	2	3	4
Cod	0,0803	0,1620	0,1222	0,0940	0,0000
Fulmar	0,0033	0,0027	0,0000	0,0000	0,0000
G. gurnards	0,1075	0,0640	0,0167	0,0000	0,0000
GBB, Gull	0,0007	0,0004	0,0000	0,0000	0,0000
Gannet	0,0000	0,0000	0,0000	0,0000	0,0000
Greyseal	0,0000	0,0014	0,0018	0,0018	0,0000
Guillemot	0,0000	0,0000	0,0000	0,0000	0,0000
H. porpoise	0,0011	0,0000	0,0000	0,0000	0,0000
Haddock	0,1136	0,1374	0,0762	0,0429	0,0000
Hake	0,0561	0,0894	0,0894	0,0894	0,0000
Her. Gull	0,0025	0,0013	0,0000	0,0000	0,0000
Kittiwake	0,0000	0,0000	0,0000	0,0000	0,0000
N. mackerel	0,0118	0,0012	0,0000	0,0000	0,0000
N. horsemac	0,0000	0,0000	0,0000	0,0000	0,0000
Puffin	0,0000	0,0000	0,0000	0,0000	0,0000
R. radiata	0,0337	0,0133	0,0000	0,0000	0,0000
Razorbill	0,0000	0,0009	0,0000	0,0000	0,0000
Saithe	0,1954	0,5428	0,5428	0,5428	0,0000
W. mackerel	0,3373	0,0129	0,0000	0,0000	0,0000
W. horsemac	0,0018	0,0000	0,0000	0,0000	0,0000
Whiting	0,4672	0,3447	0,2324	0,1633	0,0000

Table 5. Average 1974-2013) partial predation mortality from SMS by age group (0-3) of Norway pout (NP Age) and predator age group (0-10) by predator. (SMS 2013 baseline run).

NP Age	Pred. Age / Predator	0	1	2	3	4	5	6	7	8	9	10
0	Cod	0,000	0,044	0,017	0,010	0,005	0,003	0,001	0,001	0,000	0,000	0,000
	G. gurnards	0,000	0,000	0,000	0,086	0,022	0,000	0,000	0,000	0,000	0,000	0,000
	Haddock	0,000	0,046	0,030	0,019	0,009	0,004	0,002	0,001	0,001	0,000	0,000
	Hake	0,000	0,002	0,024	0,029	0,000	0,000	0,000	0,000	0,000	0,000	0,000
	Saithe	0,000	0,000	0,000	0,062	0,042	0,029	0,021	0,015	0,010	0,007	0,009
	W. mackerel	0,000	0,000	0,030	0,060	0,061	0,052	0,134	0,000	0,000	0,000	0,000
	Whiting	0,348	0,058	0,034	0,017	0,006	0,002	0,001	0,000	0,000	0,000	0,000
1	Cod	0,000	0,068	0,046	0,024	0,013	0,006	0,003	0,001	0,001	0,000	0,000
	G. gurnards	0,000	0,000	0,000	0,026	0,038	0,000	0,000	0,000	0,000	0,000	0,000
	Haddock	0,000	0,000	0,061	0,039	0,019	0,009	0,004	0,003	0,001	0,000	0,001
	Hake	0,000	0,000	0,055	0,034	0,000	0,000	0,000	0,000	0,000	0,000	0,000
	Saithe	0,000	0,000	0,000	0,159	0,114	0,082	0,058	0,042	0,029	0,020	0,038
	W. mackerel	0,000	0,000	0,000	0,000	0,000	0,002	0,011	0,000	0,000	0,000	0,000
	Whiting	0,000	0,181	0,091	0,045	0,018	0,006	0,002	0,001	0,000	0,000	0,000
2	Cod	0,000	0,028	0,046	0,024	0,013	0,006	0,003	0,001	0,001	0,000	0,000
	G. gurnards	0,000	0,000	0,000	0,000	0,017	0,000	0,000	0,000	0,000	0,000	0,000
	Haddock	0,000	0,000	0,000	0,039	0,019	0,009	0,004	0,003	0,001	0,000	0,001
	Hake	0,000	0,000	0,055	0,034	0,000	0,000	0,000	0,000	0,000	0,000	0,000
	Saithe	0,000	0,000	0,000	0,159	0,114	0,082	0,058	0,042	0,029	0,020	0,038
	W. mackerel	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000
	Whiting	0,000	0,069	0,091	0,045	0,018	0,006	0,002	0,001	0,000	0,000	0,000
3	Cod	0,000	0,000	0,046	0,024	0,013	0,006	0,003	0,001	0,001	0,000	0,000
	G. gurnards	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000
	Haddock	0,000	0,000	0,000	0,013	0,014	0,007	0,004	0,003	0,001	0,000	0,001
	Hake	0,000	0,000	0,055	0,034	0,000	0,000	0,000	0,000	0,000	0,000	0,000
	Saithe	0,000	0,000	0,000	0,159	0,114	0,082	0,058	0,042	0,029	0,020	0,038
	W. mackerel	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000
	Whiting	0,000	0,000	0,091	0,045	0,018	0,006	0,002	0,001	0,000	0,000	0,000

Table 6. Main predator age groups of Norway pout by species, i.e. age groups where Norway pout has high importance as prey, according to the latest (2013) multi-species SMS model base-line run for the North Sea.

Species	Main importance	Focus ages in analyses
Cod	Age 2 and older	Age 2-4
Whiting	Age 2 and older	Age 2-4
Haddock	Age 3 and older	Age 3-4
Saithe	Age 2 and older	Age 2-4
Pollack	Age 2 and older	Age 2-4
W. mackerel	Age 2 and older	Age 2-6
G. gurnard	Age 3 and older	Age 3-4

In **Figures 31-32** the relationship between predator spawning stock biomass (**Fig. 31**) and total stock biomass (**Fig. 32**) for North Sea cod, haddock, saithe and whiting is shown as function of the Norway pout (prey) total stock biomass in the North Sea and Skagerrak estimated as 3 year running means during the period 1983-2014.

The results indicate that there is a moderate positive correlation between cod spawning stock biomass and Norway pout total stock biomass, while there is no correlation between whiting and haddock spawning stock biomasses and Norway pout total stock biomass, and there is even a slight negative correlation between saithe spawning stock biomass and Norway pout total stock biomass. There are moderate positive correlations between North Sea cod, whiting and haddock total stock biomasses and Norway pout total stock biomass, while there is no (or even with negative tendency) correlation between North Sea saithe total stock biomass and Norway pout total stock biomass.

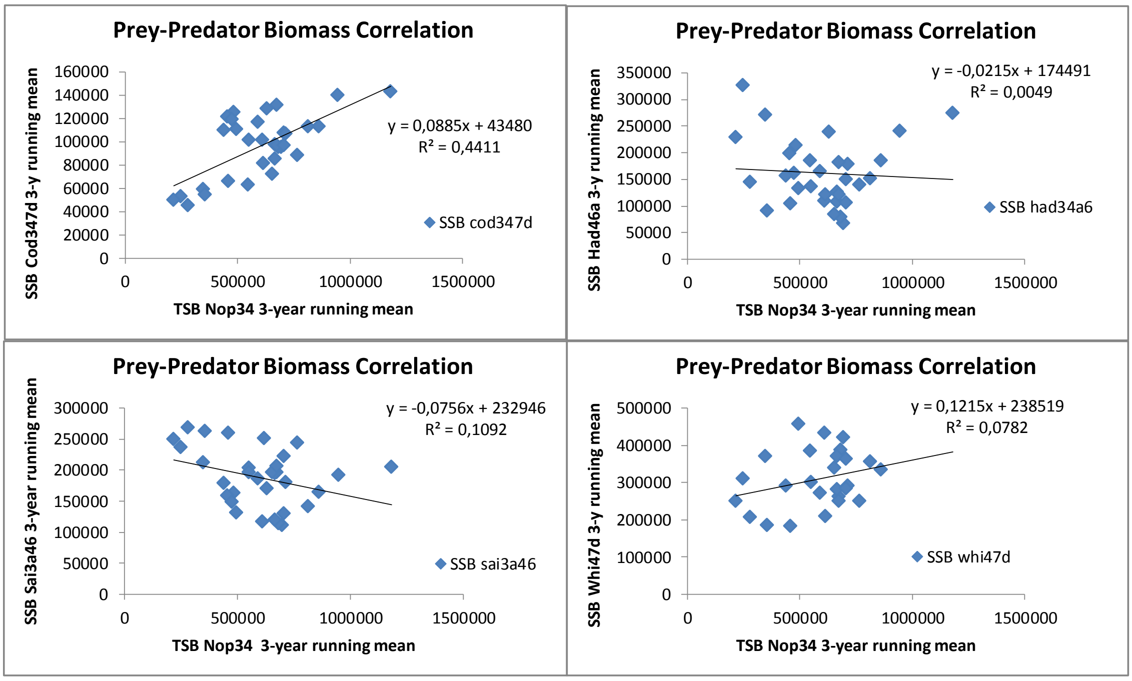


Figure 31. Relationship between cod predator spawning stock biomass in first quarter of the year as function of Norway pout prey Total Stock Biomass (TSB) in third quarter of the year. The values are 3 year running means for the period 1983-2014. Data originates from the (predators) ICES WGNSSK Stock Assessment autumn 2015 (NP) and spring 2016 (predators).

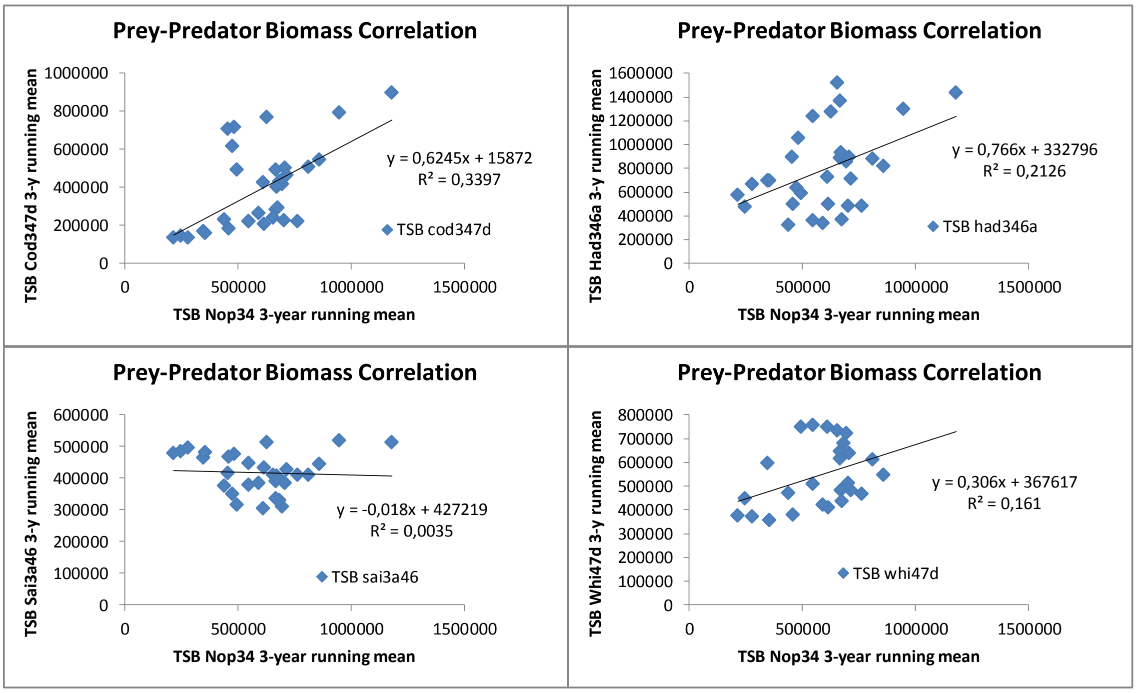


Figure 32. Correlation between predator Total Stock Biomass (TSB) in first quarter of the year as 3 year running mean values and Norway pout Total Stock Biomass (TSB) in third quarter of the year as 3 year running mean values for the period 1983 to 2014. Data from ICES

WGNSSK Single Stock Assessments in the spring 2016 (predators) and autumn 2015 (Norway pout).

Growth rates of predators versus prey biomass are given as 3 years running means for different main Norway pout predators during the period 1983 to 2014 in **Figures 33-36**. The growth rates are calculated as change in mean weight at age (MWA) of the predators where MWA values in the stock are obtained from the ICES WGNSSK spring 2016 assessments. The growth rates are calculated on cohort basis for the main age groups of the predators with respect to predation on Norway pout and where there are a high number of observations on MWA are available. The MWA is calculated as:

$$\delta w_{a_t} = w_{a_t} - w_{a-1_{t-1}}$$

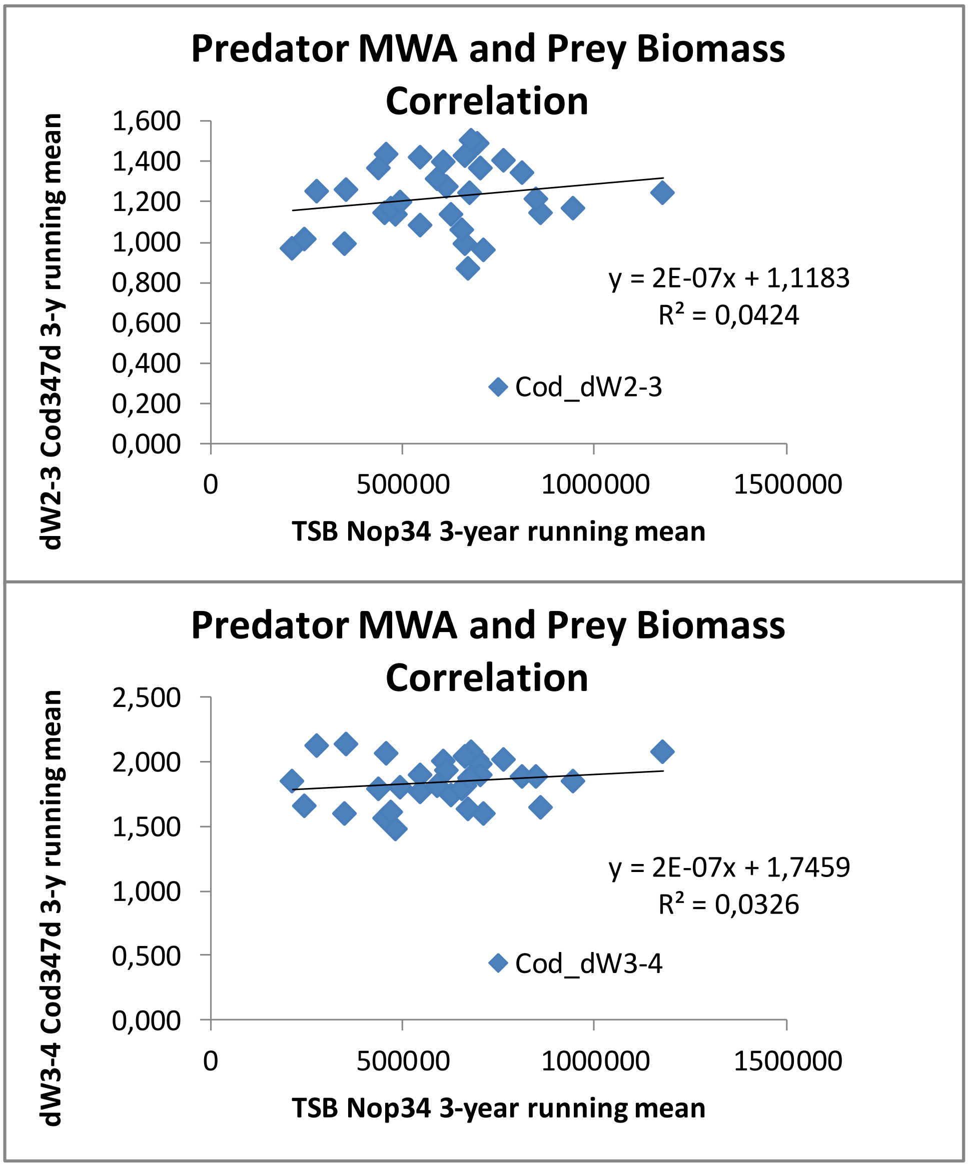


Figure 33. Correlation between Cod Mean Weight at Age (MWA) in quarter 1 from the ICES WGNSSK spring 2016 single stock assessment and Total Stock Biomass (TSB) of Norway pout in the third quarter. The values are 3 year running means of cohort growth for the period 1983-2014.

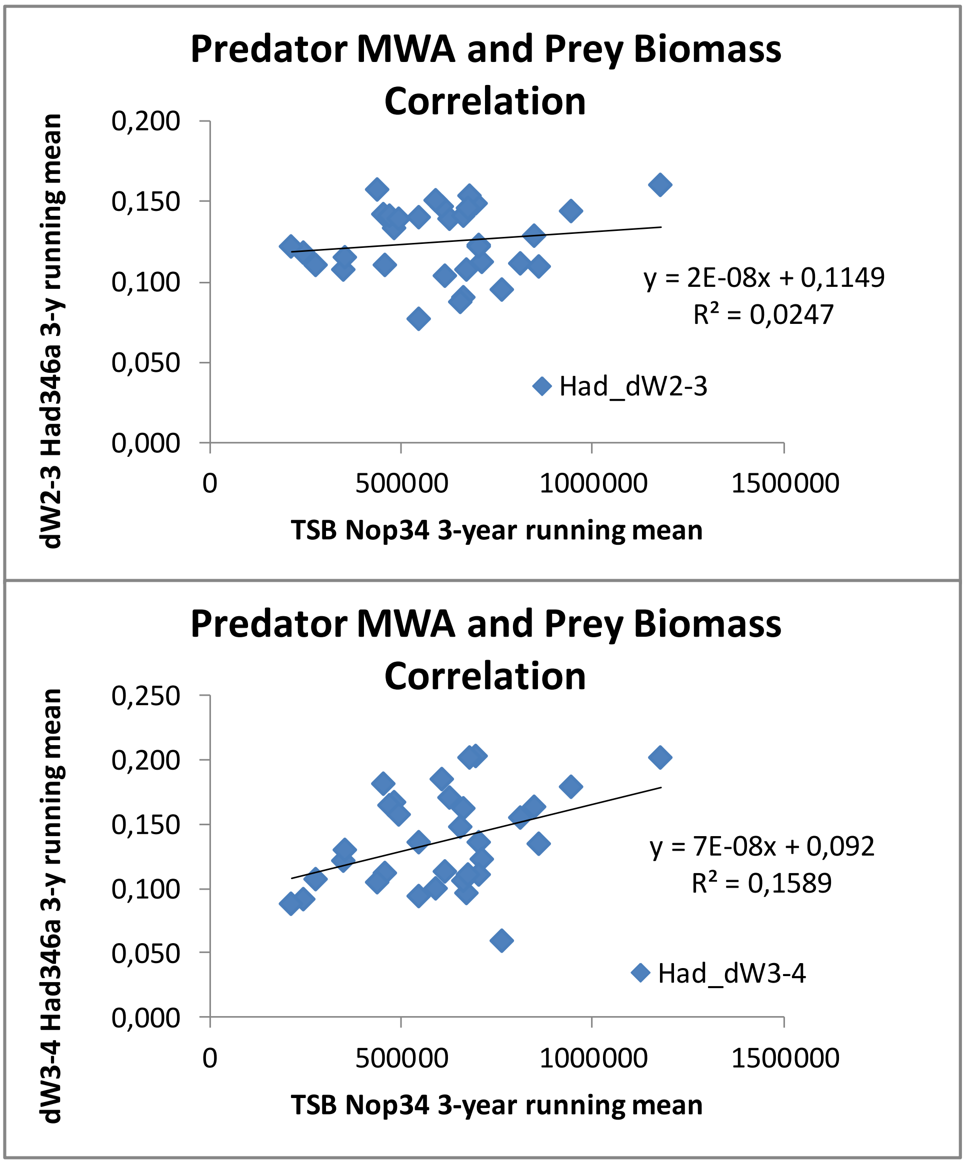


Figure 34. Correlation between Haddock Mean Weight at Age (MWA) in quarter 1 from the ICES WGNSSK spring 2016 single stock assessment and Total Stock Biomass (TSB) of Norway pout in the third quarter. The values are 3 year running means of cohort growth for the period 1983-2014.

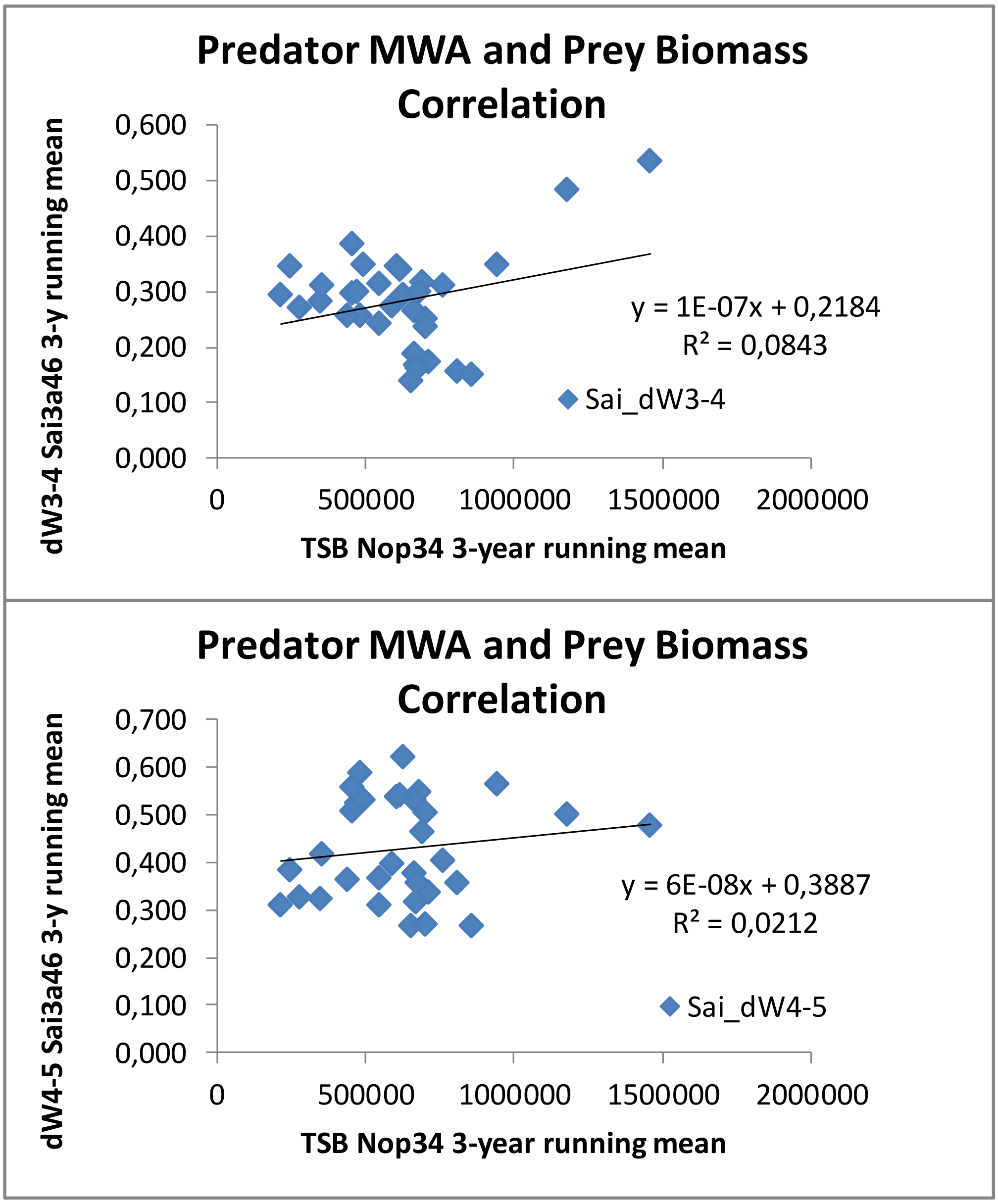


Figure 35. Correlation between Saithe Mean Weight at Age (MWA) in quarter 1 from the ICES WGNSSK spring 2016 single stock assessment and Total Stock Biomass (TSB) of Norway pout in the third quarter. The values are 3 year running means of cohort growth for the period 1983-2014.

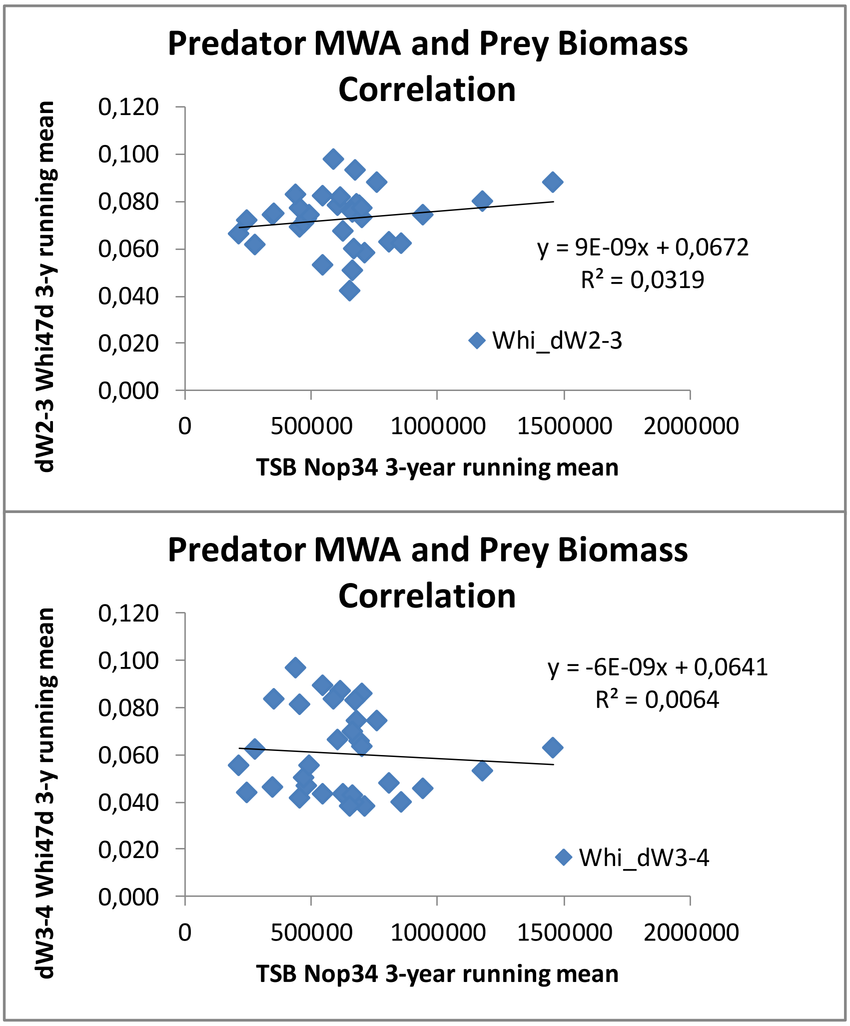


Figure 36. Correlation between Whiting Mean Weight at Age (MWA) in quarter 1 from the ICES WGNSSK spring 2016 single stock assessment and Total Stock Biomass (TSB) of Norway pout in the third quarter. The values are 3 year running means of cohort growth for the period 1983-2014.

The results indicate that for all the predator species (cod, haddock, whiting and saithe) and their main cohorts predating on Norway pout in the North Sea there is no correlation between their growth rate in mean weight at age and total stock biomass of Norway pout, except for a weak positive correlation between mean weight at age for 1 cohort (age 3-4) of haddock and Norway pout total stock biomass. Accordingly, growth and mean weight-at-age for a row of important predators on Norway pout in the North Sea seems not very dependent on the stock size of Norway pout.

Predator assessments in the ICES WGNSSK single stock assessments in recent years for important predators on Norway pout do not indicate serious changes in their MWA or condition and accordingly there is no indication that they starve with current level harvests of Norway pout (F-cap of 0.6 set now and max F in last 10 years at 0.5).

It should be noted that Denmark back in 2008 or so (Naturstyrelsen) have made a MSFD indicator on Saithe growth (MLA) in relation to industrial species abundance. However, this does not go specific on Norway pout but industrial or prey species in general.

7. Environmental drivers

Only limited knowledge is available on the influence of environmental factors, such as temperature, on the Norway pout recruitment.

The interplay between temperature-related processes and predation in determining age-1 recruitment strength between 1992 and 2006 was analysed for North Sea cod (*Gadus morhua*) and Norway pout (*Trisopterus esmarkii*) by Kempf et al. (2009). For this purpose, a predation impact index (PI) was calculated out of IBTS survey data. PI was assumed to depend on the abundance of the predators and on the spatial overlap between predator and prey populations. Generalized additive models (GAMs) were created with spawning stock biomass (SSB) and sea surface temperature (SST) in the respective spawning and nursery areas and PI as explaining variables. Intraspecific SSB had no significant impact on recruitment during this time period for both species. SSTs during spring and PI explained the inter-annual variability in recruitment strength to a large extent (88% of the total variance for cod and 68% for Norway pout). The SST during spring determined the overall level of recruitment. At SSTs above a certain level, however, the effect on recruitment was no longer significant. In these temperature ranges, predation was the dominant effect. On this basis, Kempf et al. (2009) stated that the fate of North Sea cod and Norway pout stocks under global-warming conditions will be strongly influenced by the status of the North Sea food web.

The data used for the analyses in Kempf et al. (2009) was IBTS survey data: North Sea wide (including the Skagerrak (ICES areas IVand IIIa)), age-recruitment indices (RI) were calculated for cod and Norway pout from age-based, first-quarter IBTS data from 1992 to 2006 (ICES 1999 – see Kempf et al. 2009). The Skagerrak was added because North Sea and Skagerrak subpopulations show high exchange rates and are treated as one stock in standard fish stock assessments (Kempf et al. 2009). The average number of age-1 recruits caught in the first quarter in each ICES rectangle (0.58 latitude 18 longitude) was calculated for each species analysed whenever more than one haul was conducted in a certain year. Later, the average catch numbers were summed over all ICES rectangles to get an age-1 recruitment index for the North Sea and Skagerrak area. Because the coverage for ICES areas IV and IIIa was complete in all years after 1991, the summation of the mean catches per ICES rectangle introduced no bias due to inter-annual changes in the number of ICES rectangles surveyed (Kempf et al. 2009).

It should again here be noted that the age length keys of Norway pout survey data from the ICES IBTS surveys used in the study by Kempf et al. (2009) were not scrutinized and analysed on a disaggregated seasonal and area basis as the results from Lambert et al. (2009) revealed were necessary to obtain precise age readings and growth data and parameters on a spatiotemporal disaggregated basis for this Norway pout stock. This can also influence recruitment estimates.

According to Kempf et al. (2009) the IBTS age-1 recruitment index for Norway pout varied considerably between the years until the year 2000. From 2000 to 2006, the recruitment index was always at a low level and less variable than in previous time periods. The time series of first-quarter SST north of 58.8N showed a significant increasing trend from 1994 onwards (Kempf et al. 2009). The SST value was outstandingly low in 1994 and extremely high in 1998. The SST during the second quarter also increased over the analysed time period; however, the trend was not found significant. As in the spawning and nursery areas of cod, the years 1992 and 1996 deviated from the general trend. SSTs during the third quarter were higher in the last third of the time series than in the previous periods. The PI values were mainly in the range of 20 000 to 60 000. In single years, however, the index was <20 000 (in 1991) or >100 000 (in 2000). Kempf et al. (2009) did not find a obvious temporal trend. Furthermore, there was found no significant relationship between SSB in the year of birth and the IBTS age-1 recruitment index of the following year. High and low recruitment index values occurred at any part of the analysed SSB spectrum. SST in the first, second, and third quarters had no significant effect on recruitment strength of Norway pout in the models with SSB and SST as the only explaining variables. The SST in the 2nd quarter, however, had the strongest relationship with the recruitment index and was close to being significant (Kempf et al. 2009), however, the effect of second-quarter SST became significant when PI was added as an explaining variable. As with cod, the age-1 recruitment index of Norway pout was higher after the cold years (1994 and 1996) than after the warmer years. For temperatures >8.5 8C, no clear effect on the recruitment index could be recognized (Kempf et al. 2009). PI had a significant negative linear effect on the Norway pout recruitment index. The final model was able to explain the recruitment of Norway pout to a satisfying extent (Kempf et al. 2009). Both variables together explained 68% of the recruitment index from 1992 to 2006. A large part of the interannual variability, however, could not be resolved with PI and SST as explaining variables. The low recruitment in 2005, especially, could not be explained; this data point appeared as an outlier in the residual plot. When fitting the model without the recruitment index for 2005, the fit became better ($R2$ =0.75) and the effects of SST and PI on recruitment were more significant. No significant correlation was found between the explaining variables, and no significant autocorrelation of the model variables was detected at any lag. Also, the residuals were not distributed differently from a normal distribution (Kempf et al. 2009).

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APPENDIX A.1

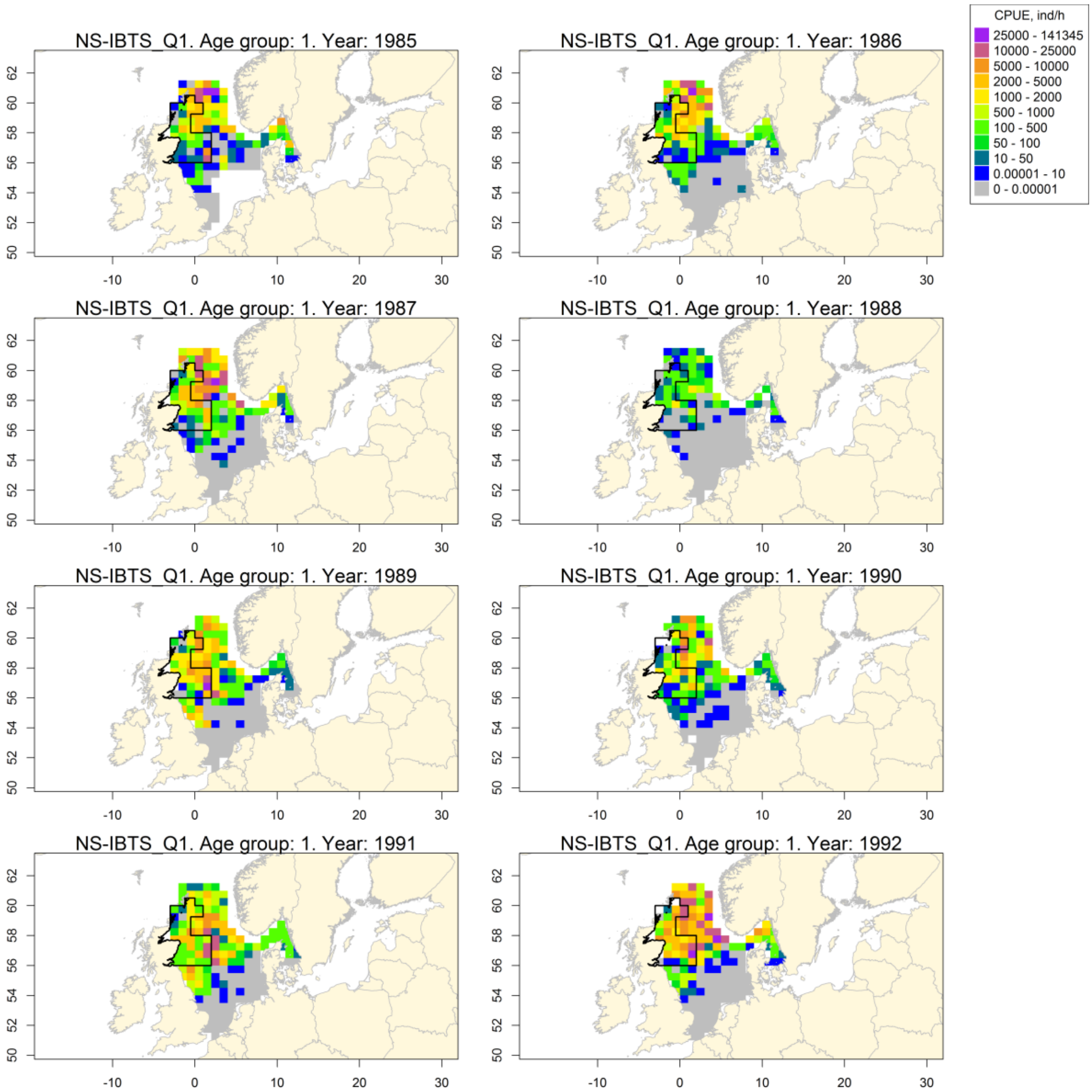
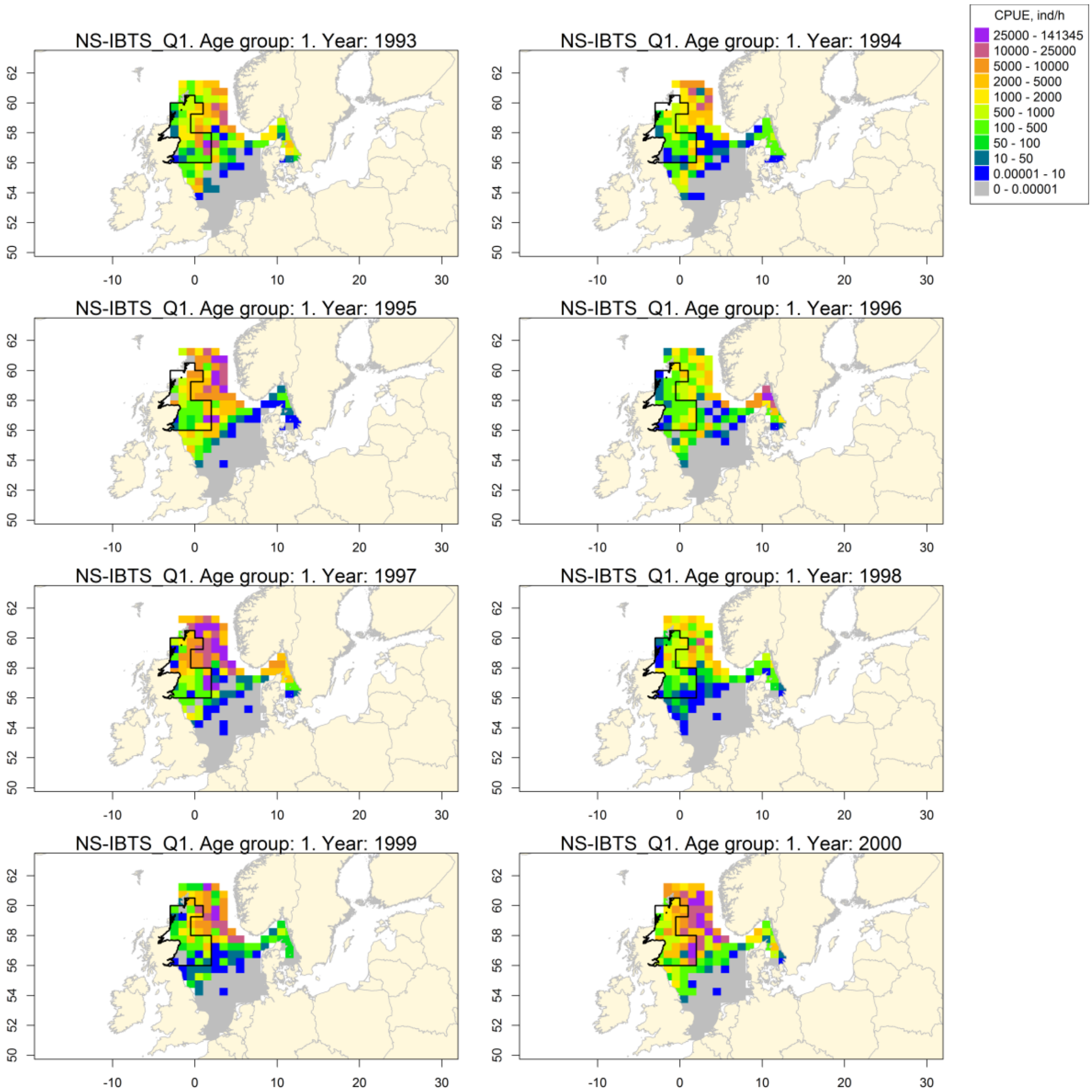


Figure A.1.1. Distribution of Norway pout by age group (ages 1-5) and year in the first quarter of the year as indicated by catch per unit of effort (CPUE) in numbers per trawl hour (N/h) estimated from the ICES IBTS Q1 survey during the period 1985-2016.



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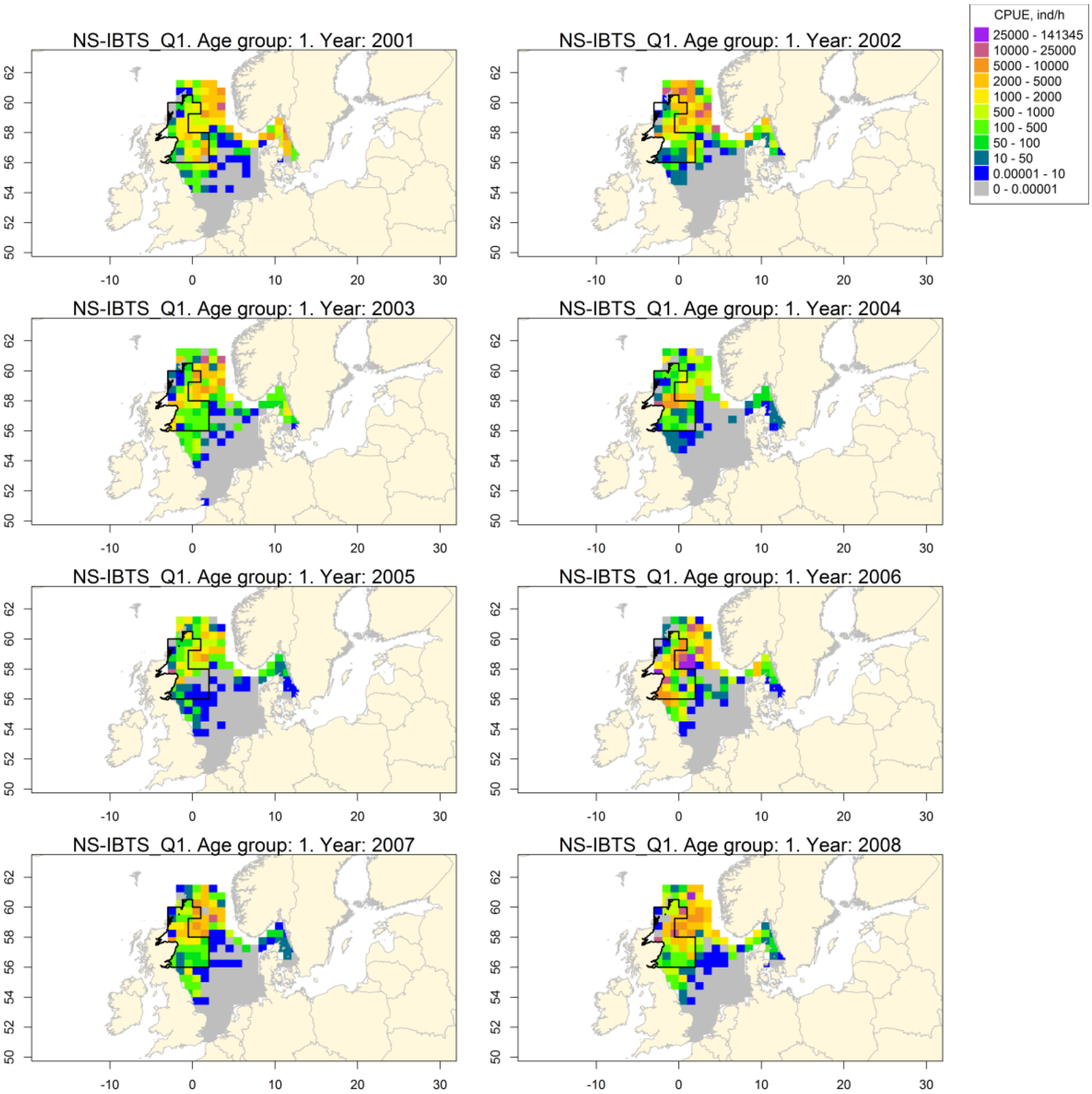

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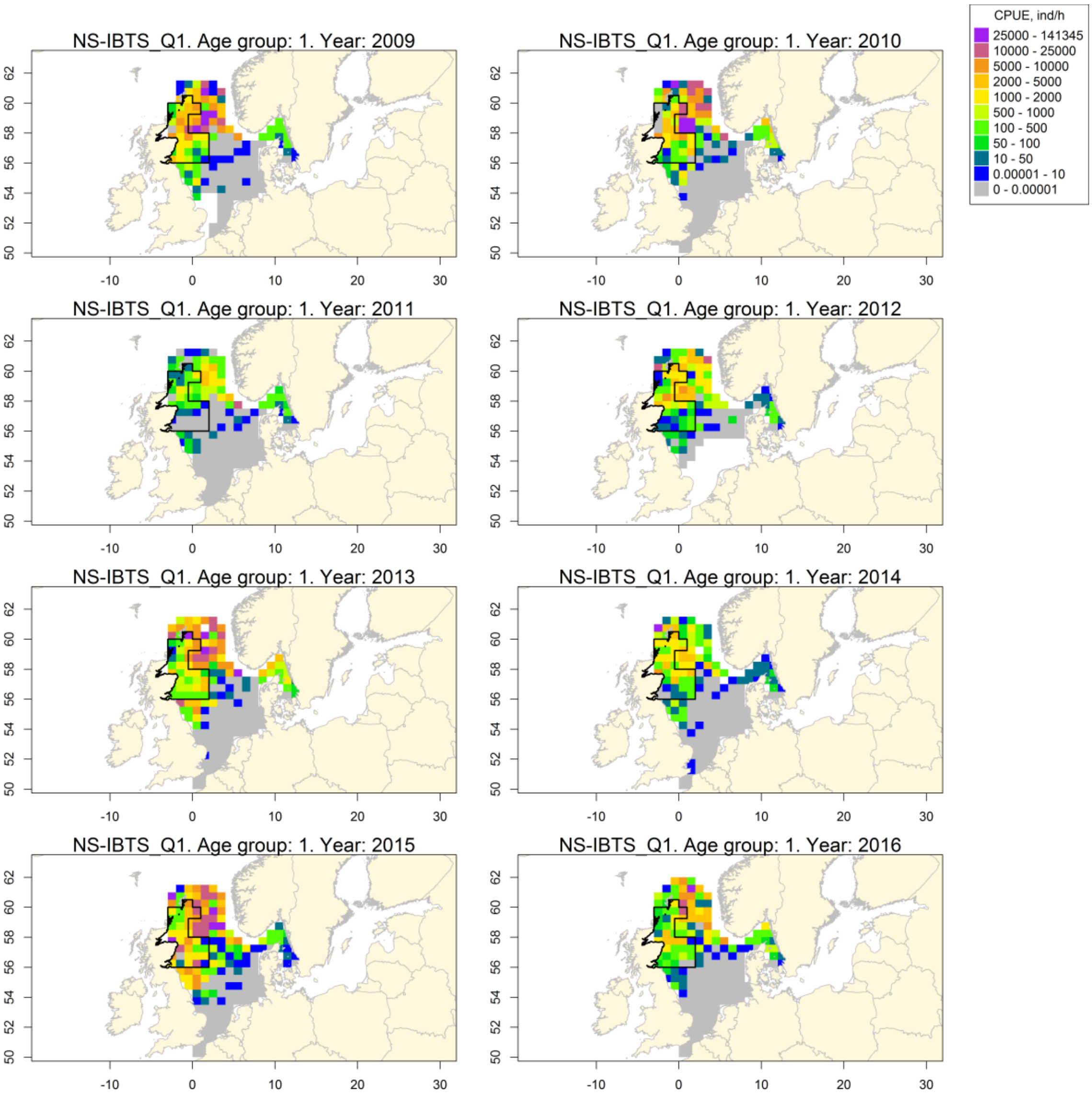

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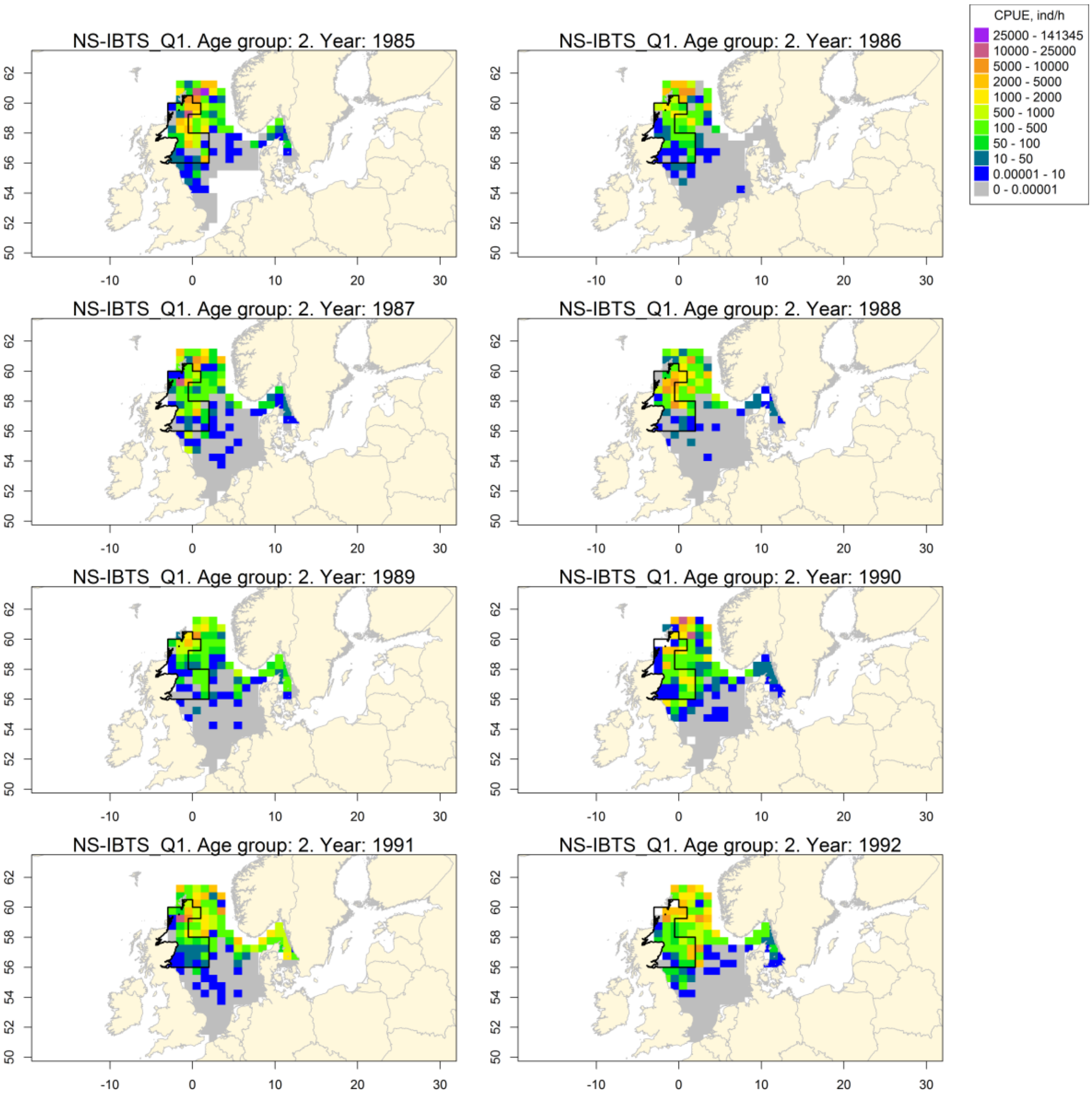

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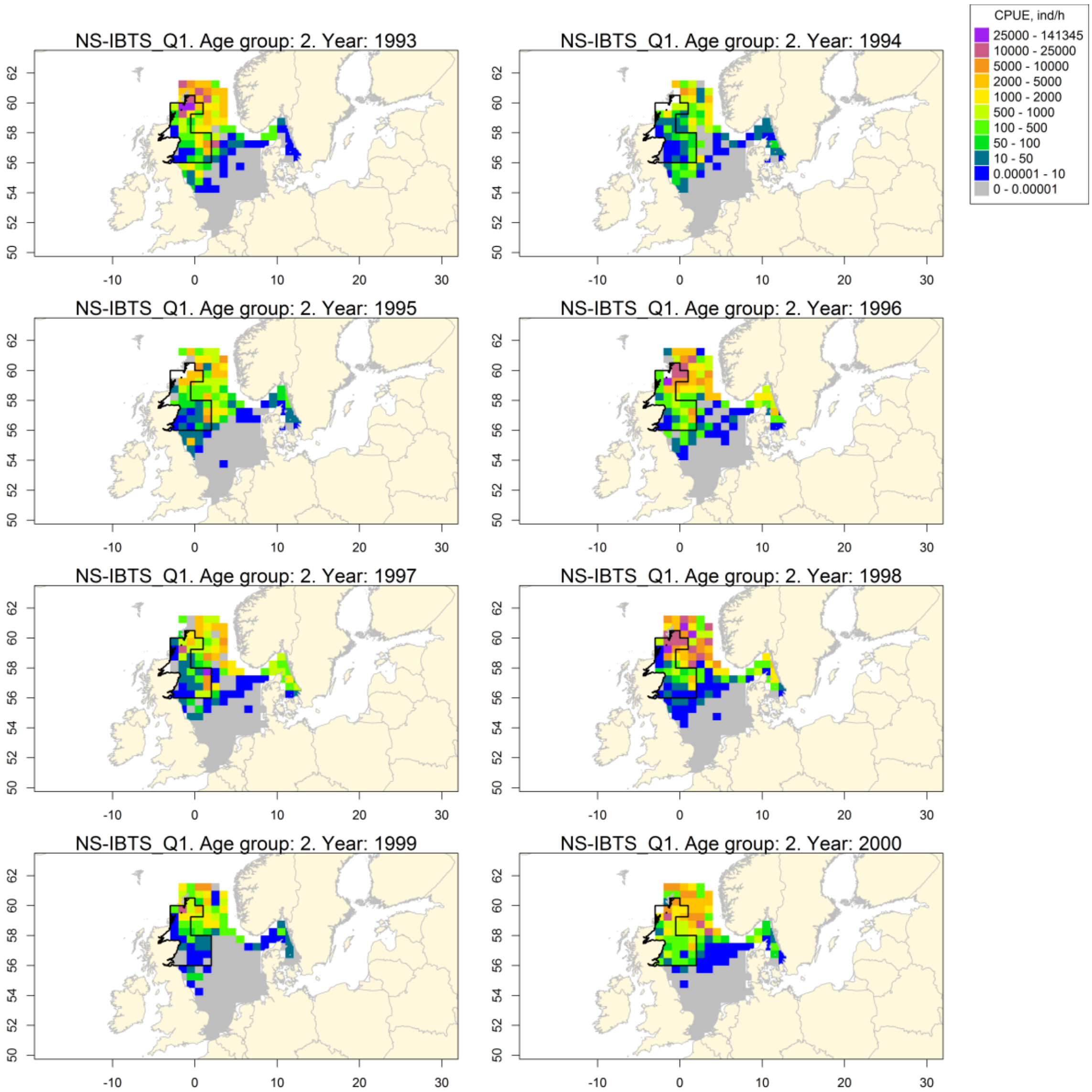

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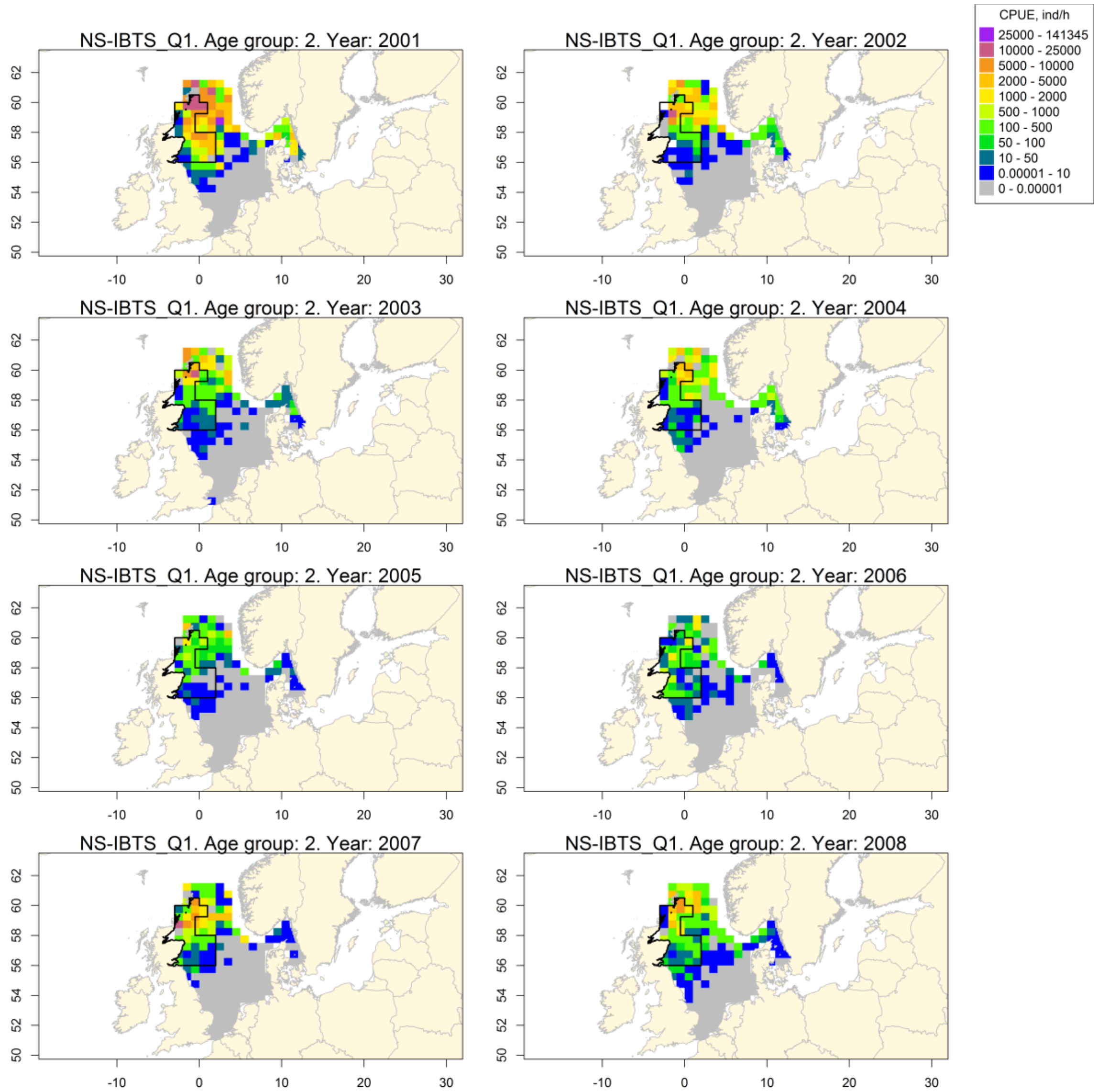

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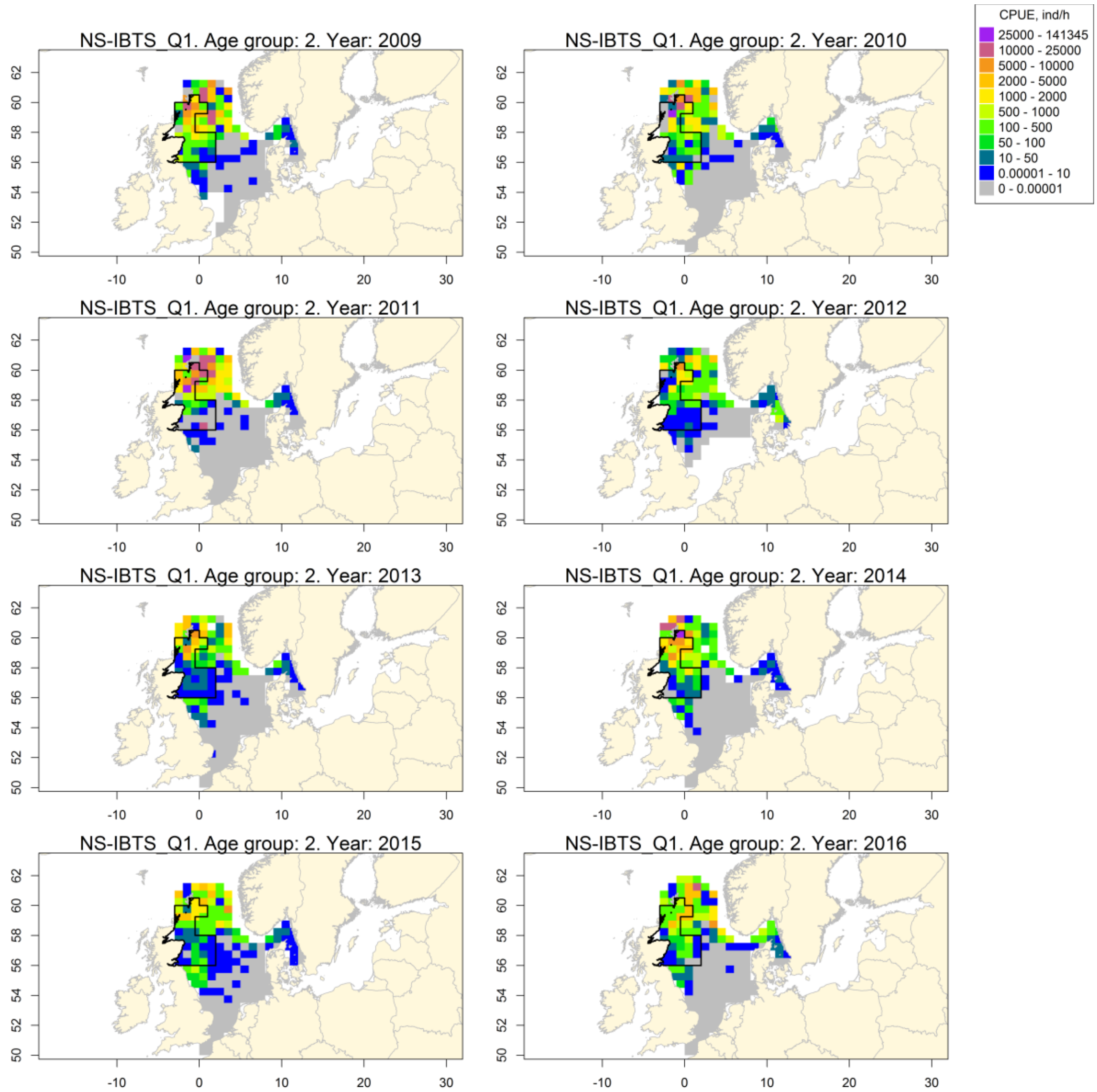

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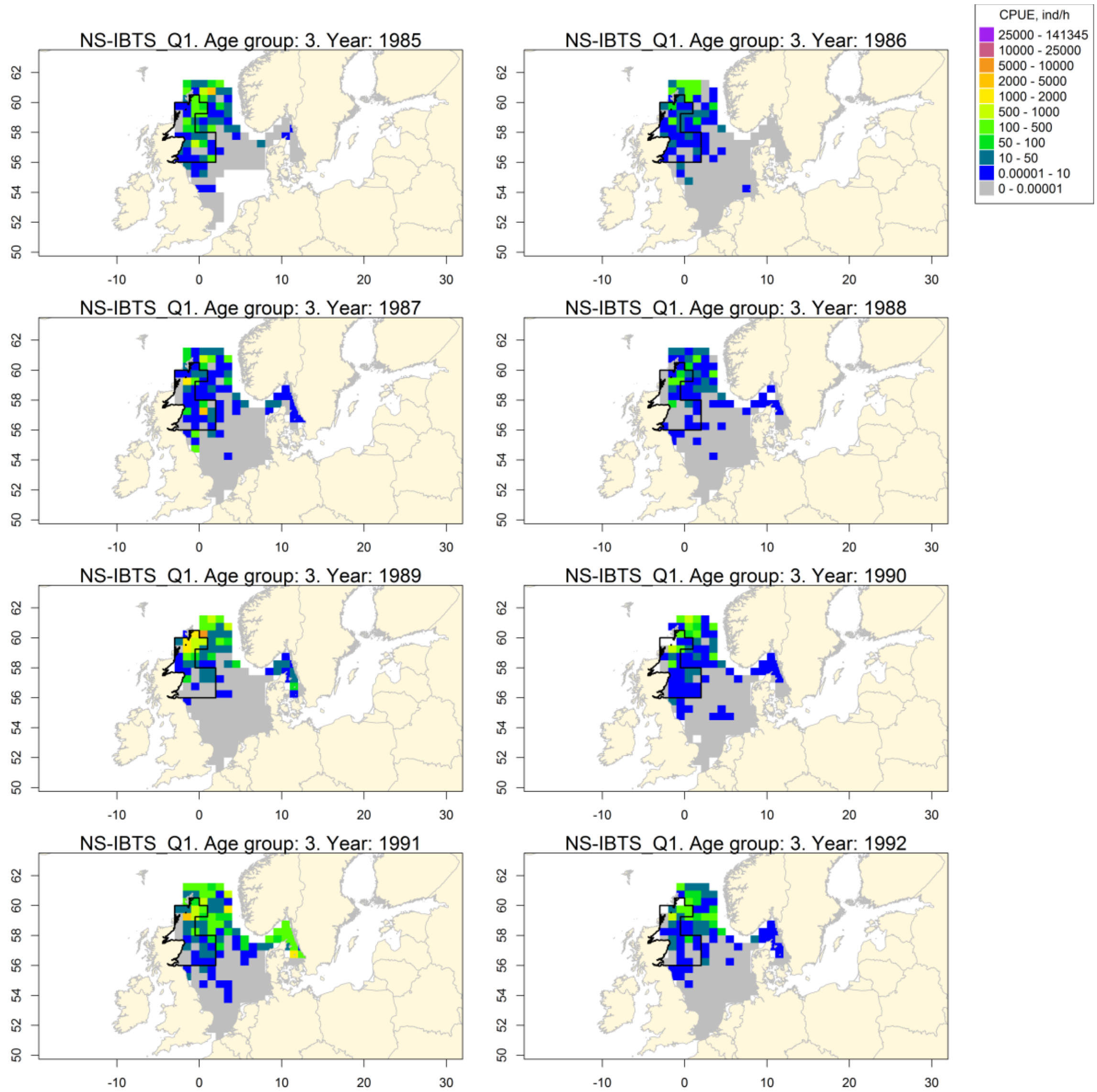

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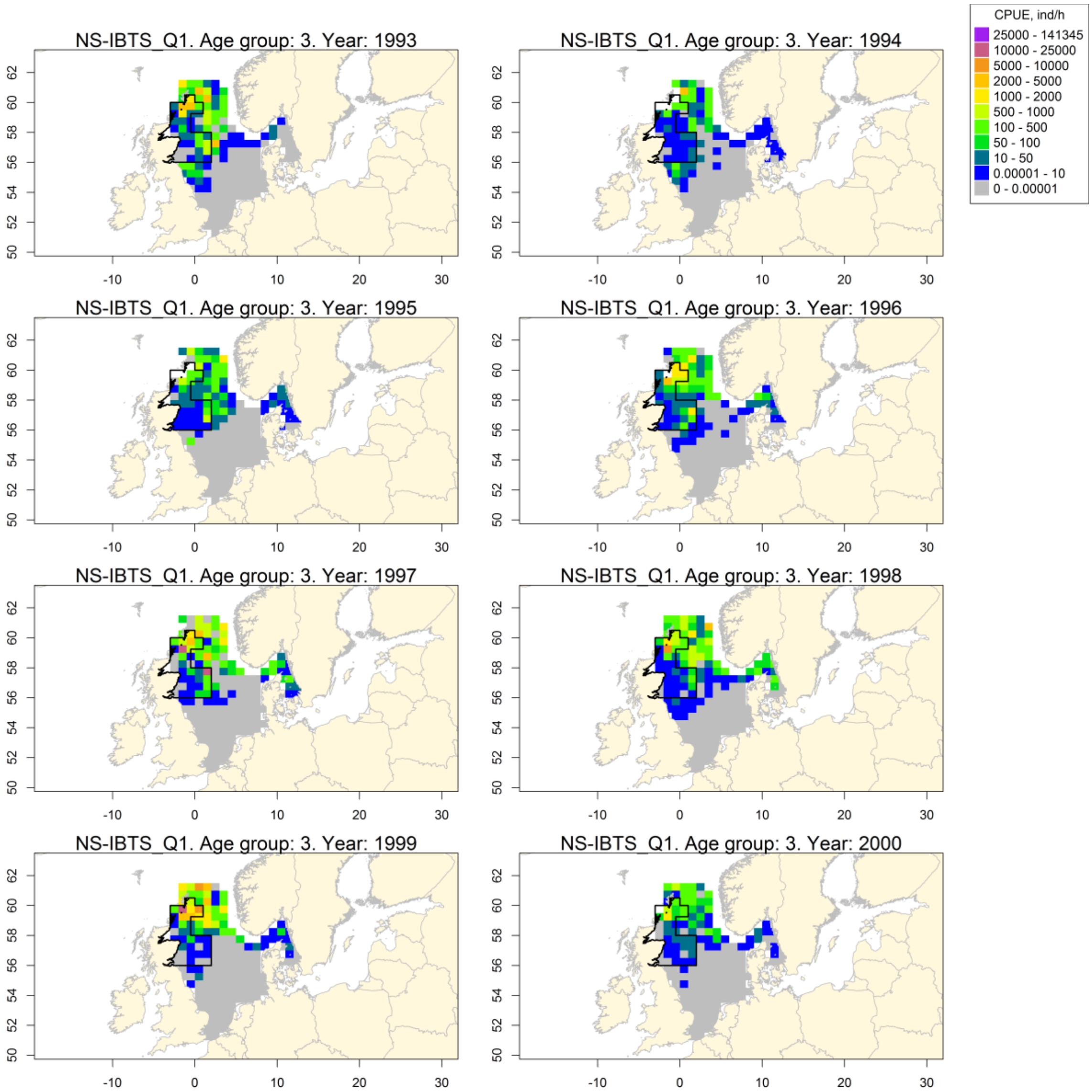

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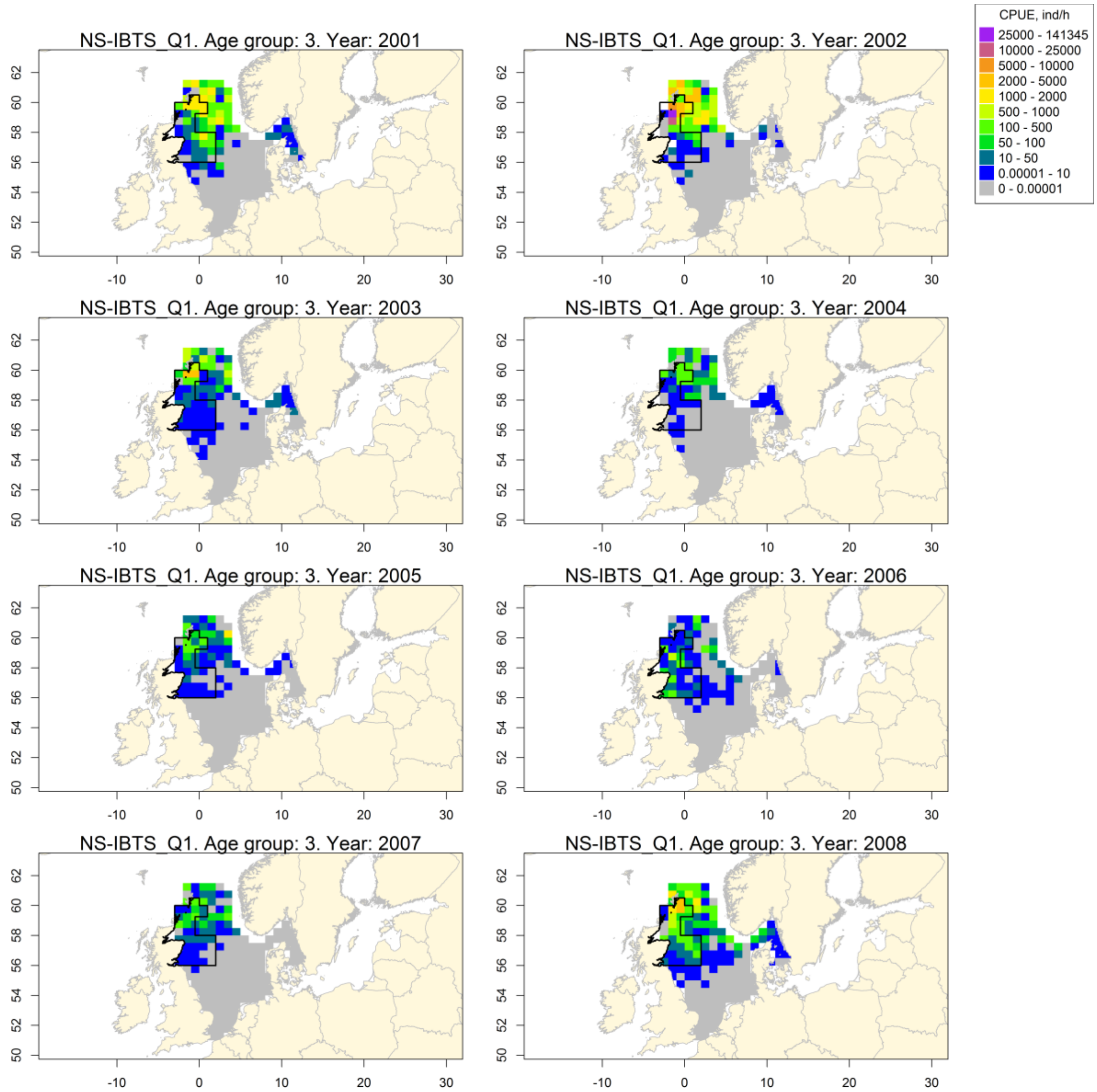

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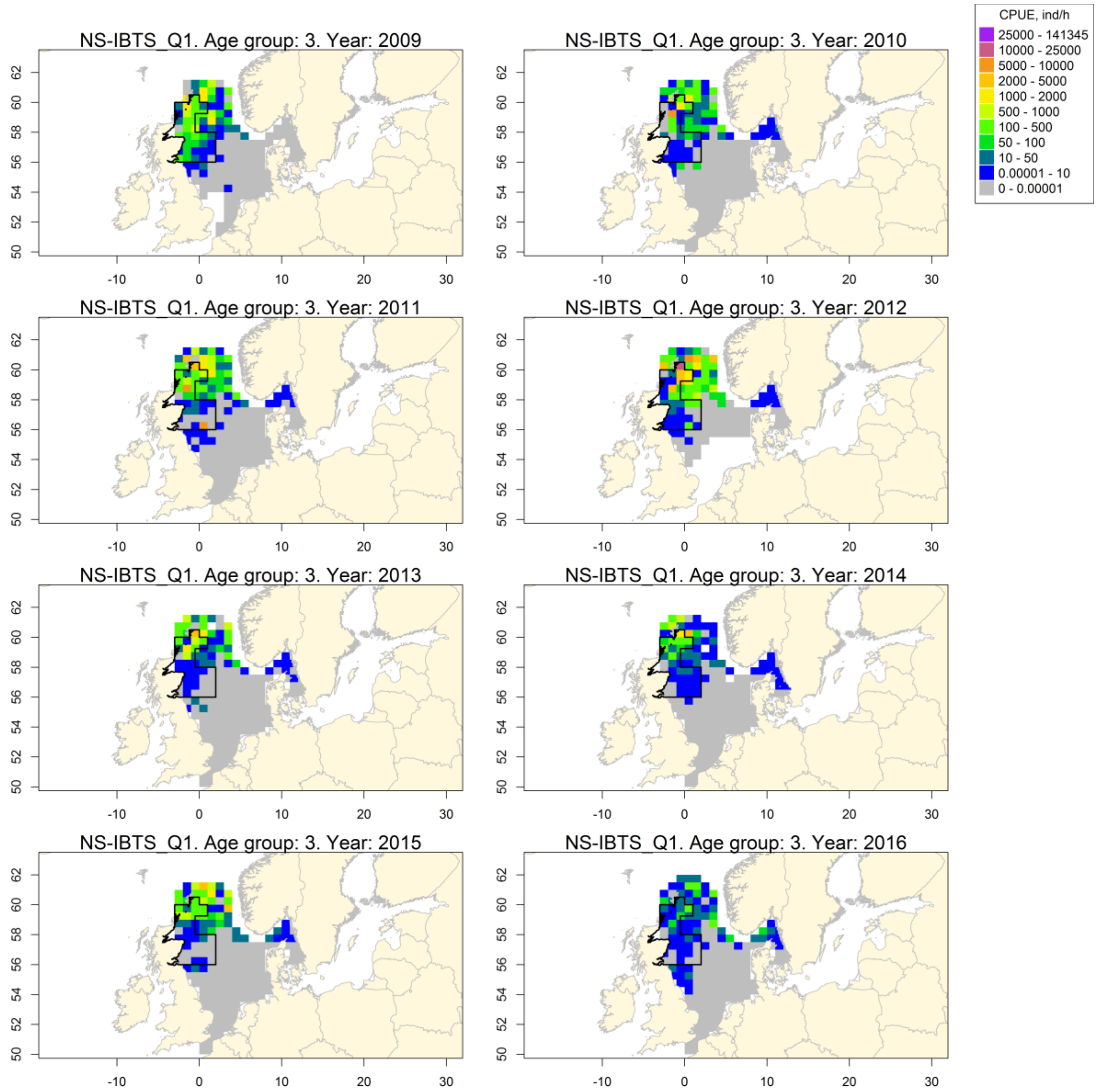

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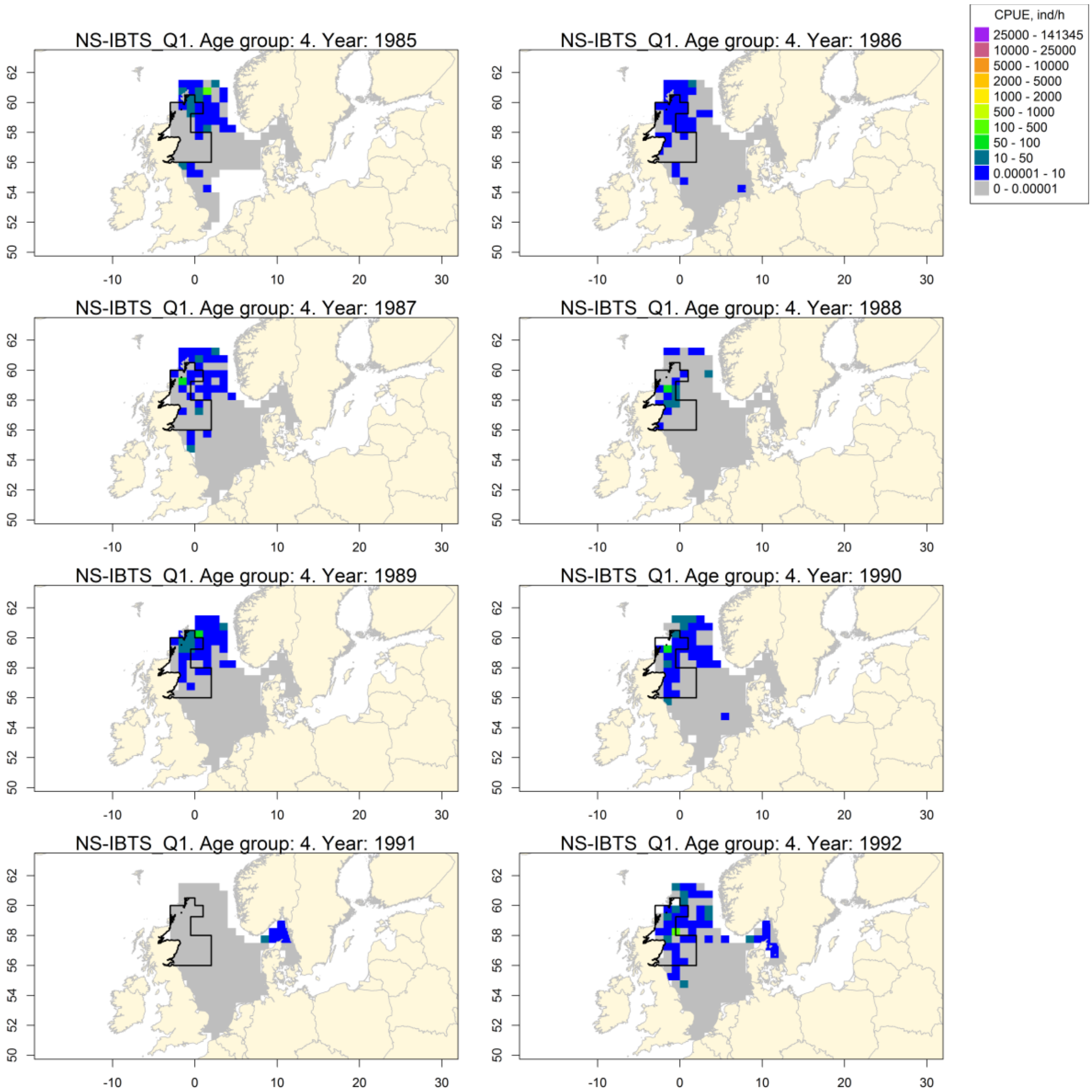

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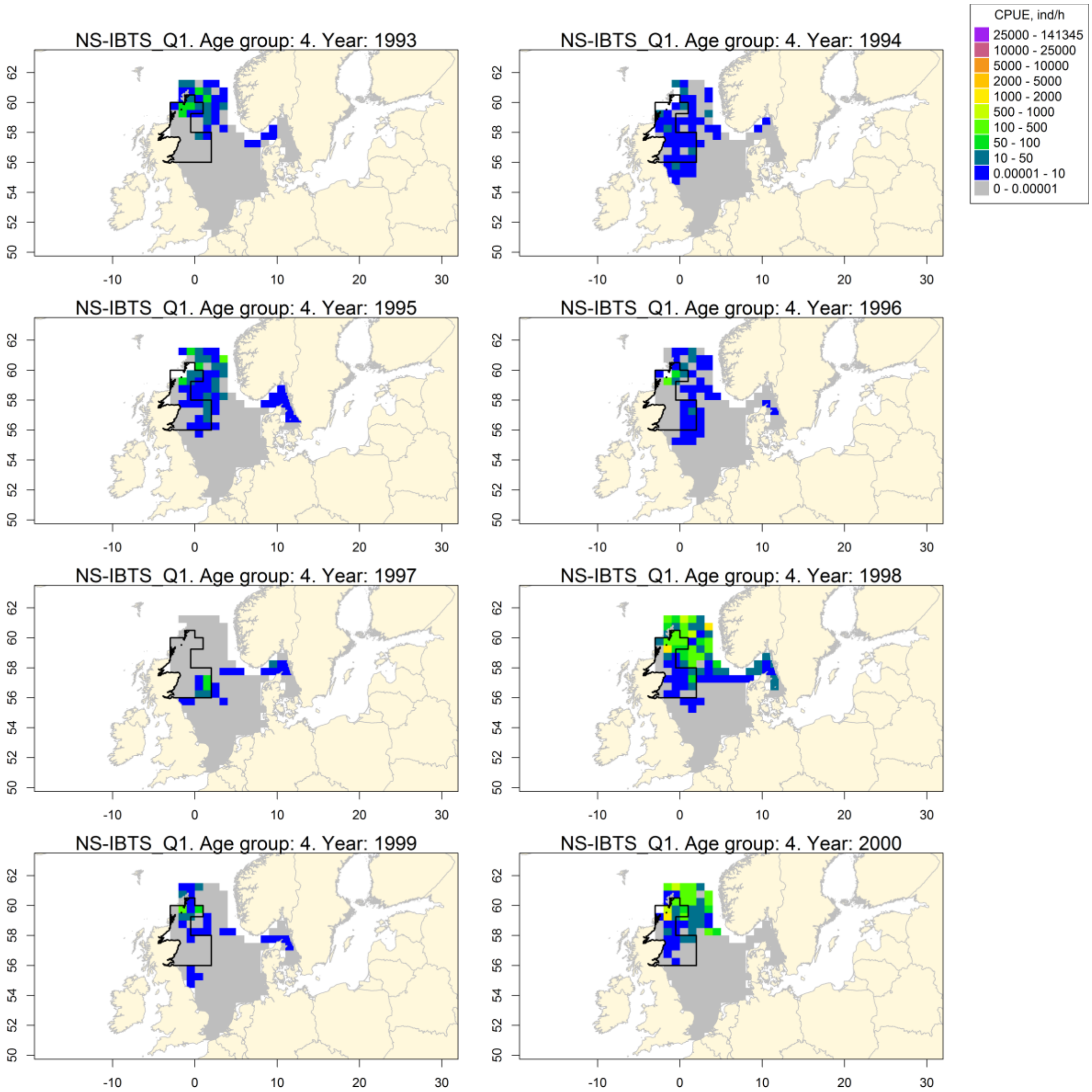

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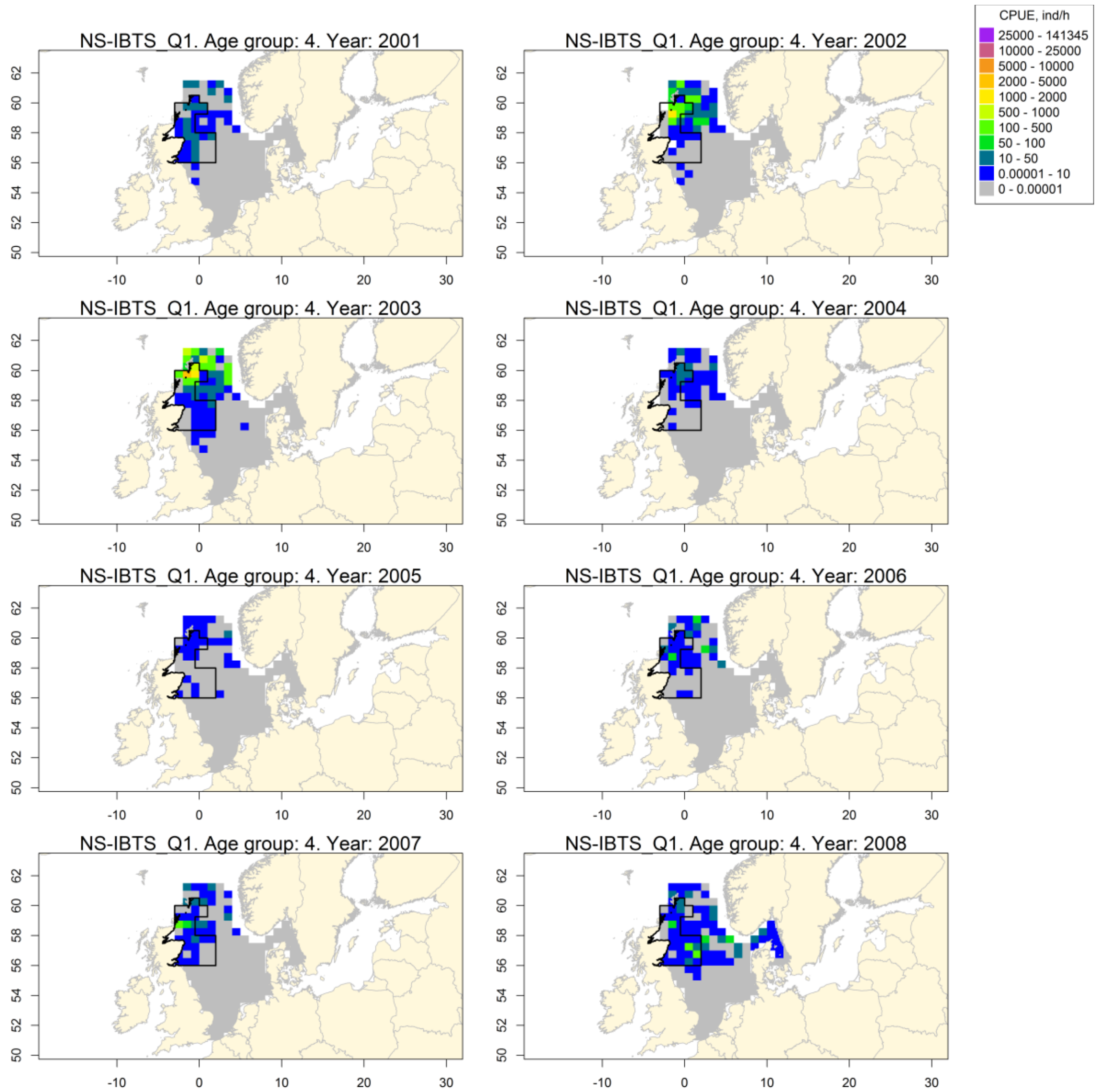

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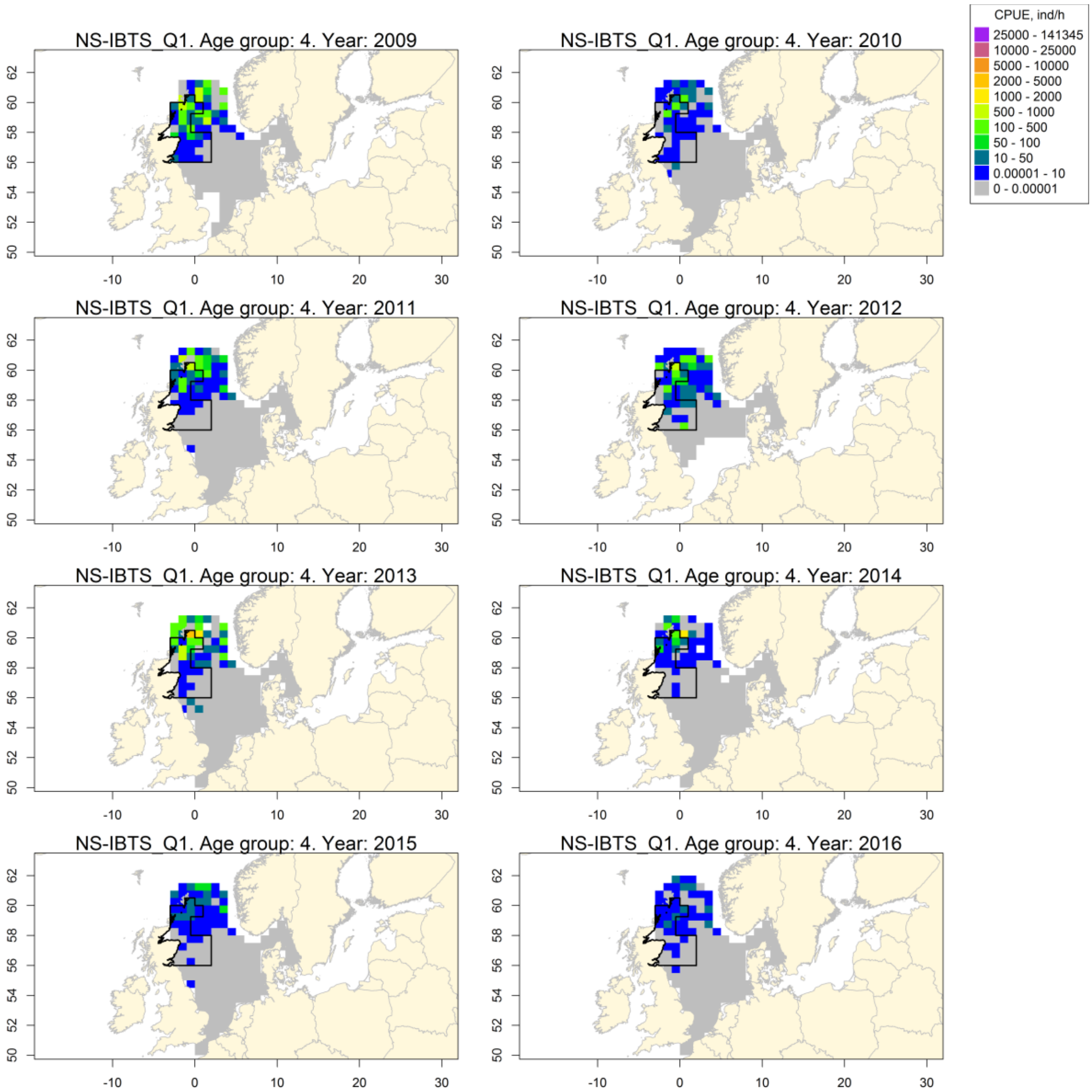

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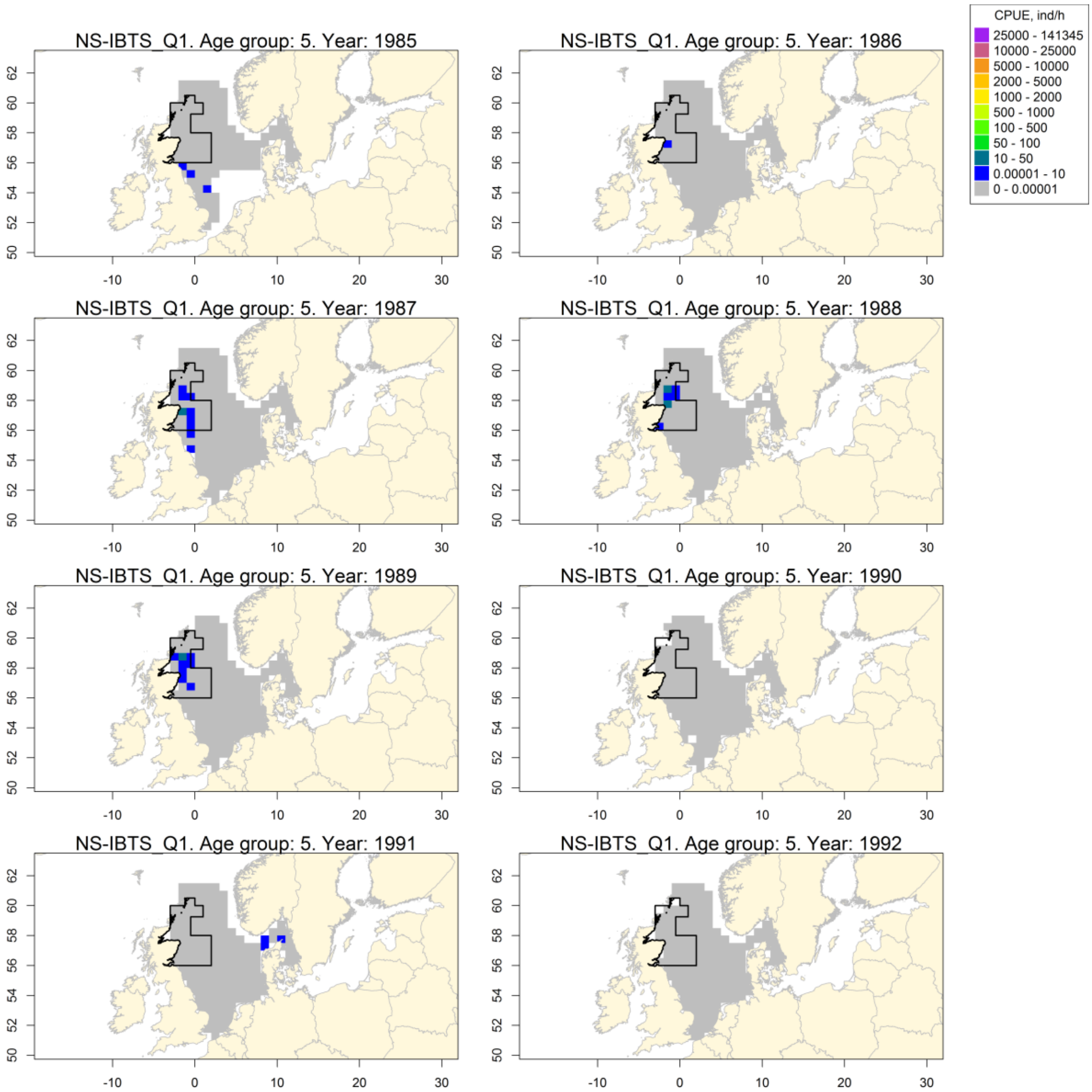

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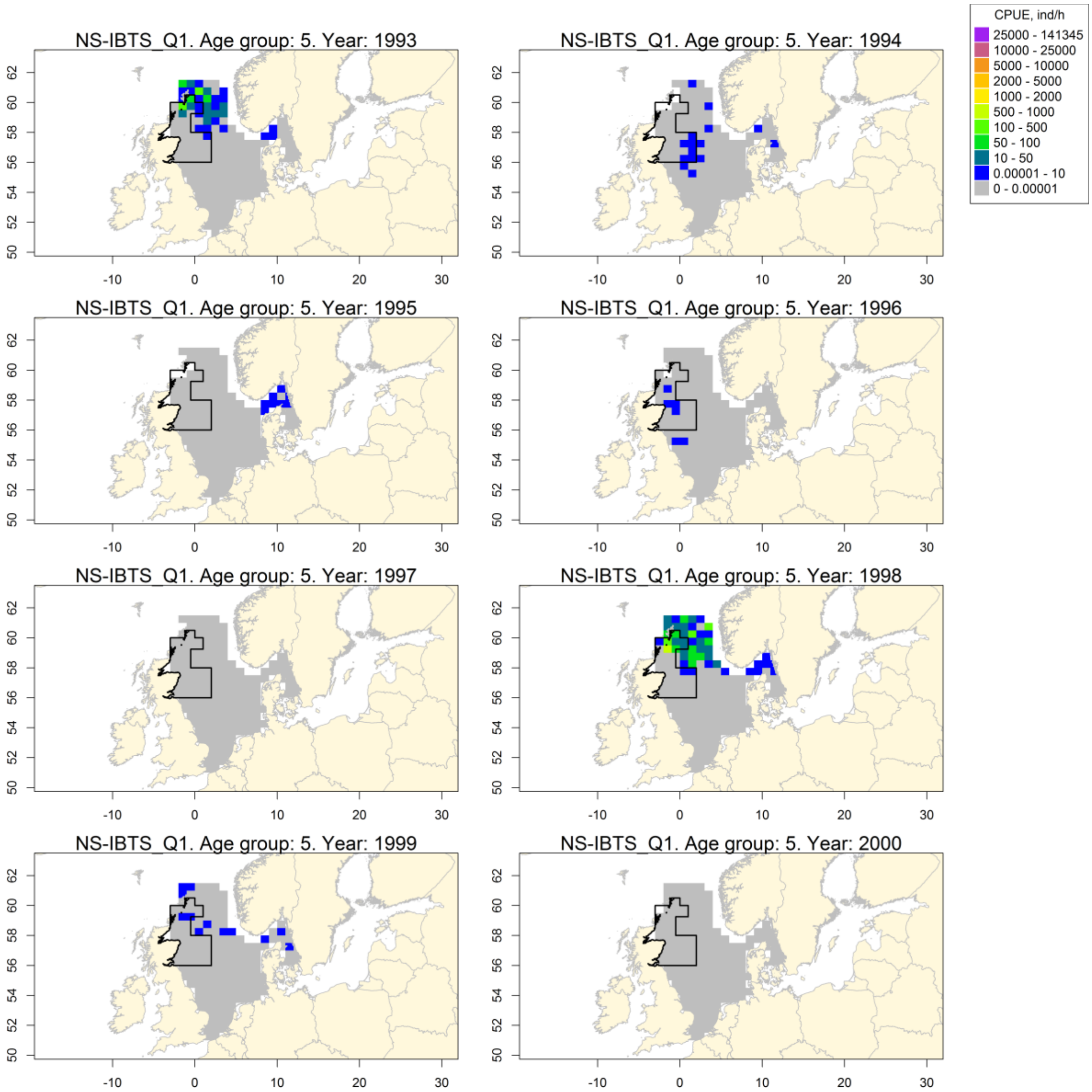

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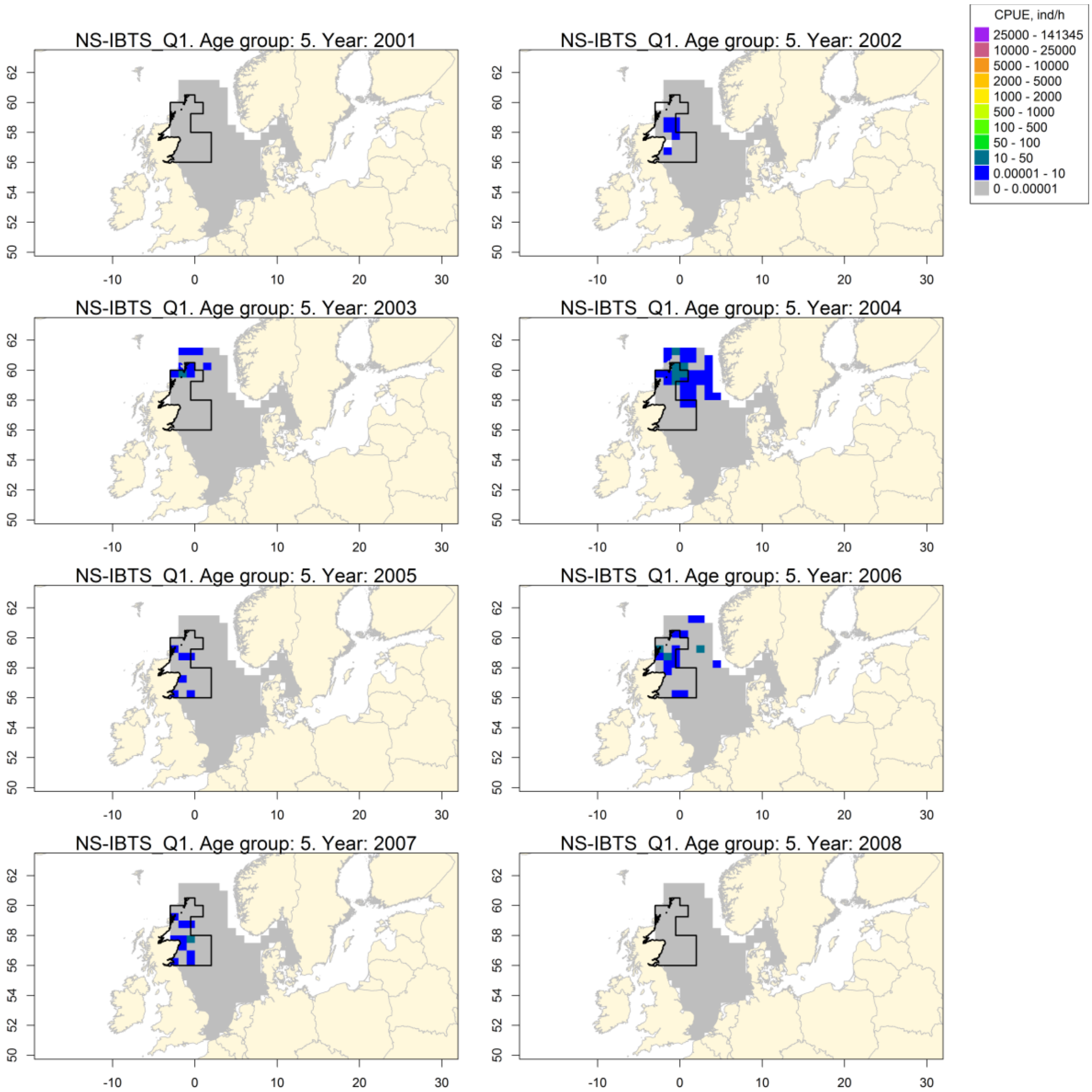

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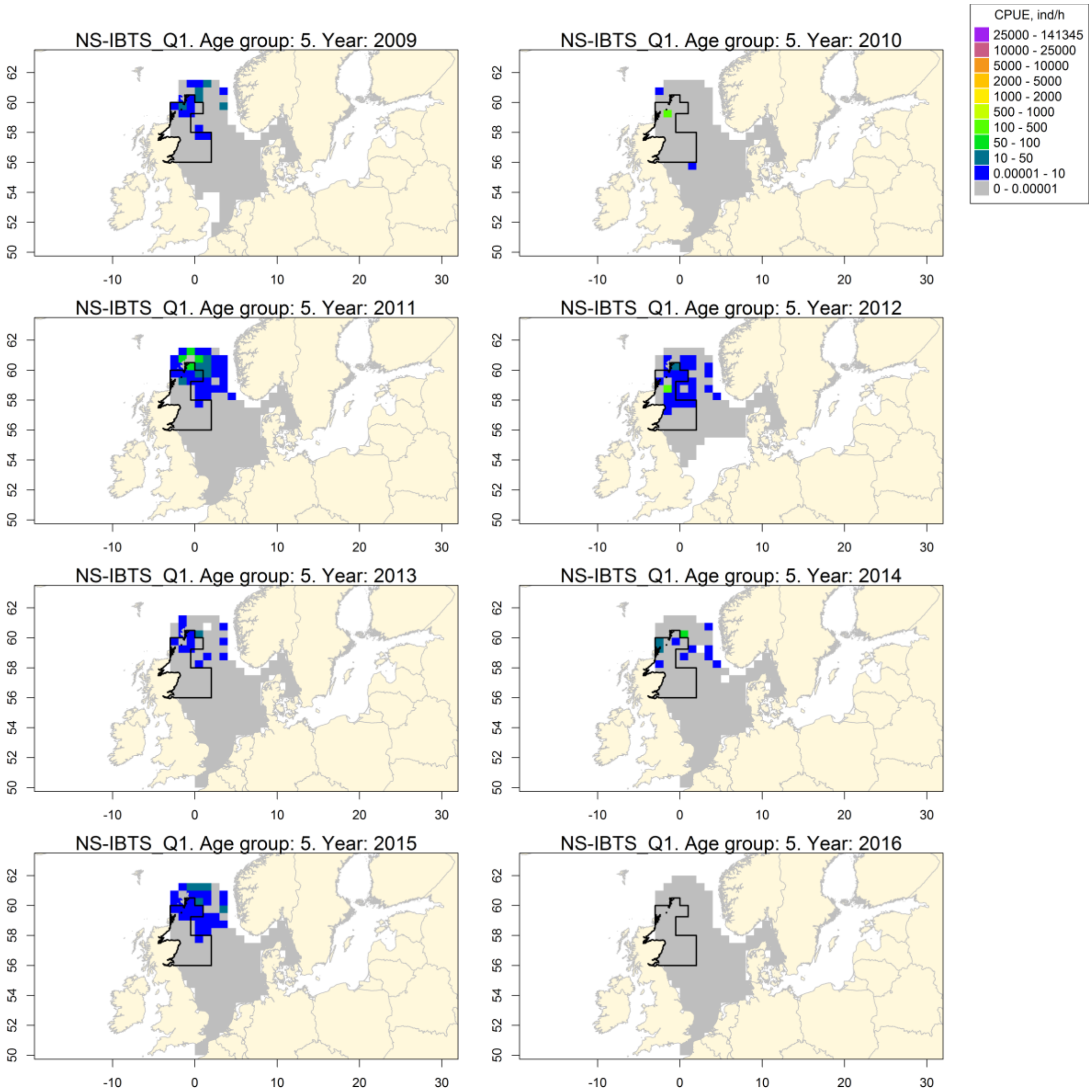

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APPENDIX A.2

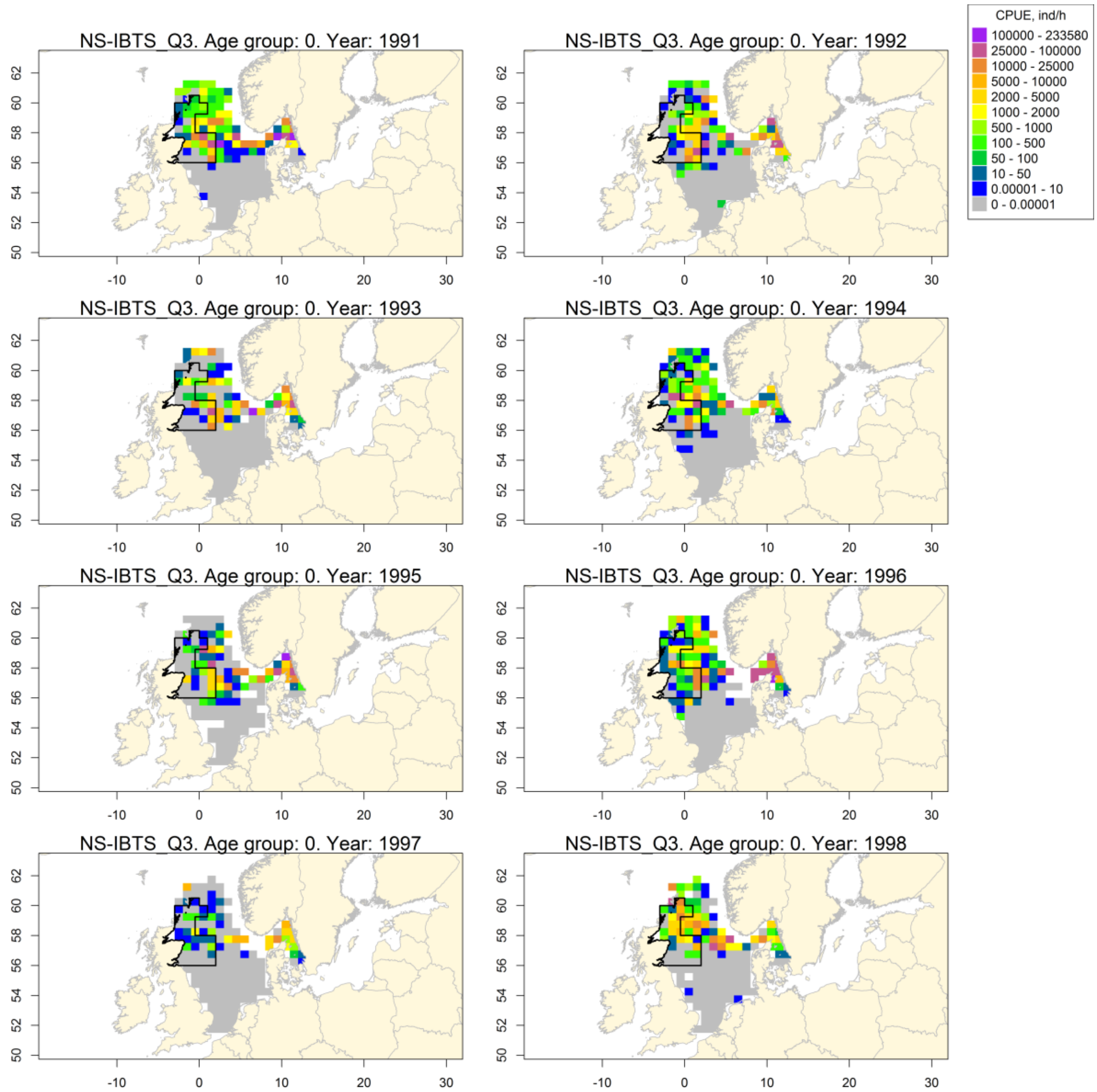
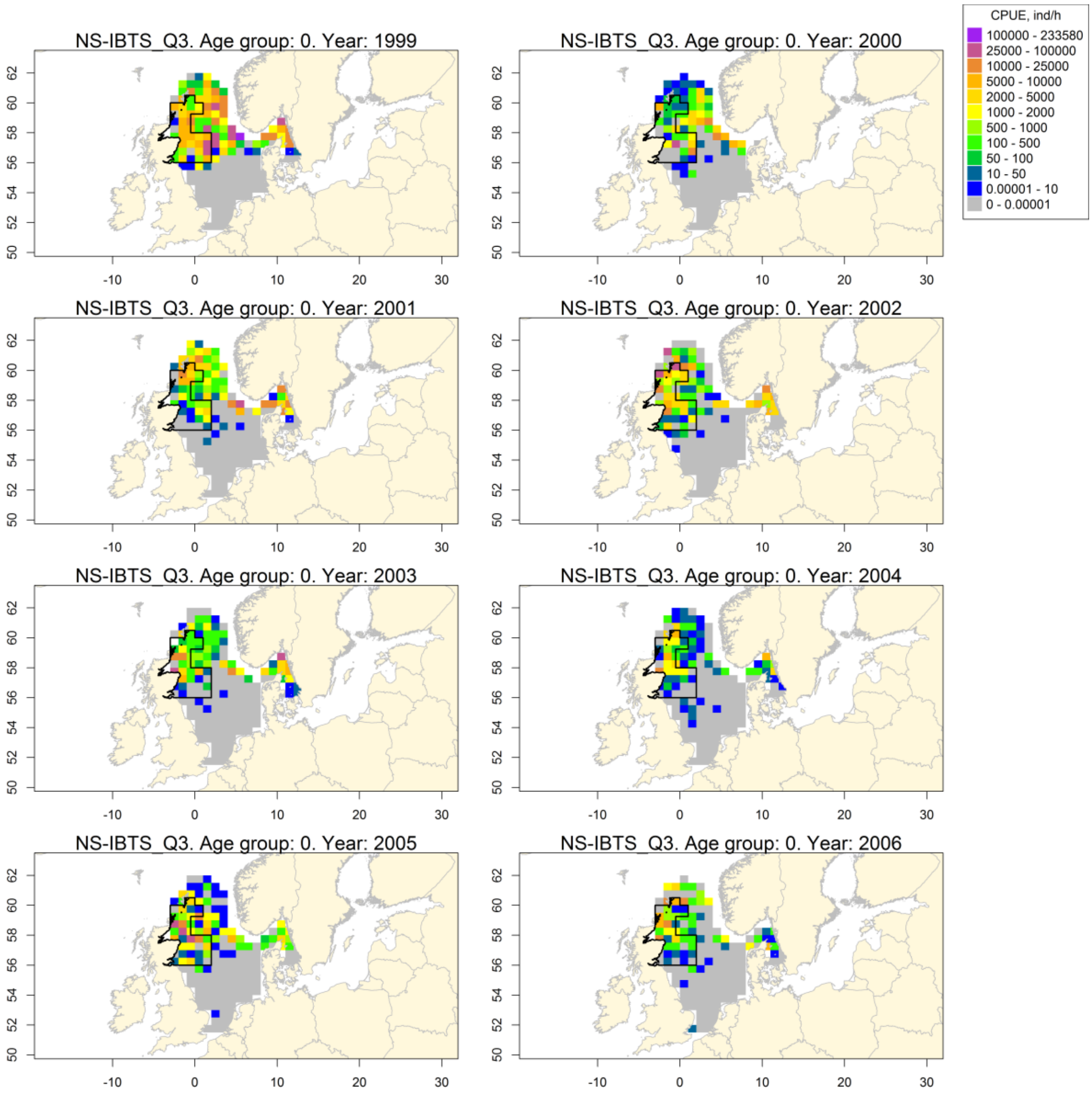


Figure A.2.1. Distribution of Norway pout by age group (ages 0-4) and year in the first quarter of the year as indicated by catch per unit of effort (CPUE) in numbers per trawl hour (N/h) as estimated from the ICES IBTS Q3 survey during the period 1991-2015.



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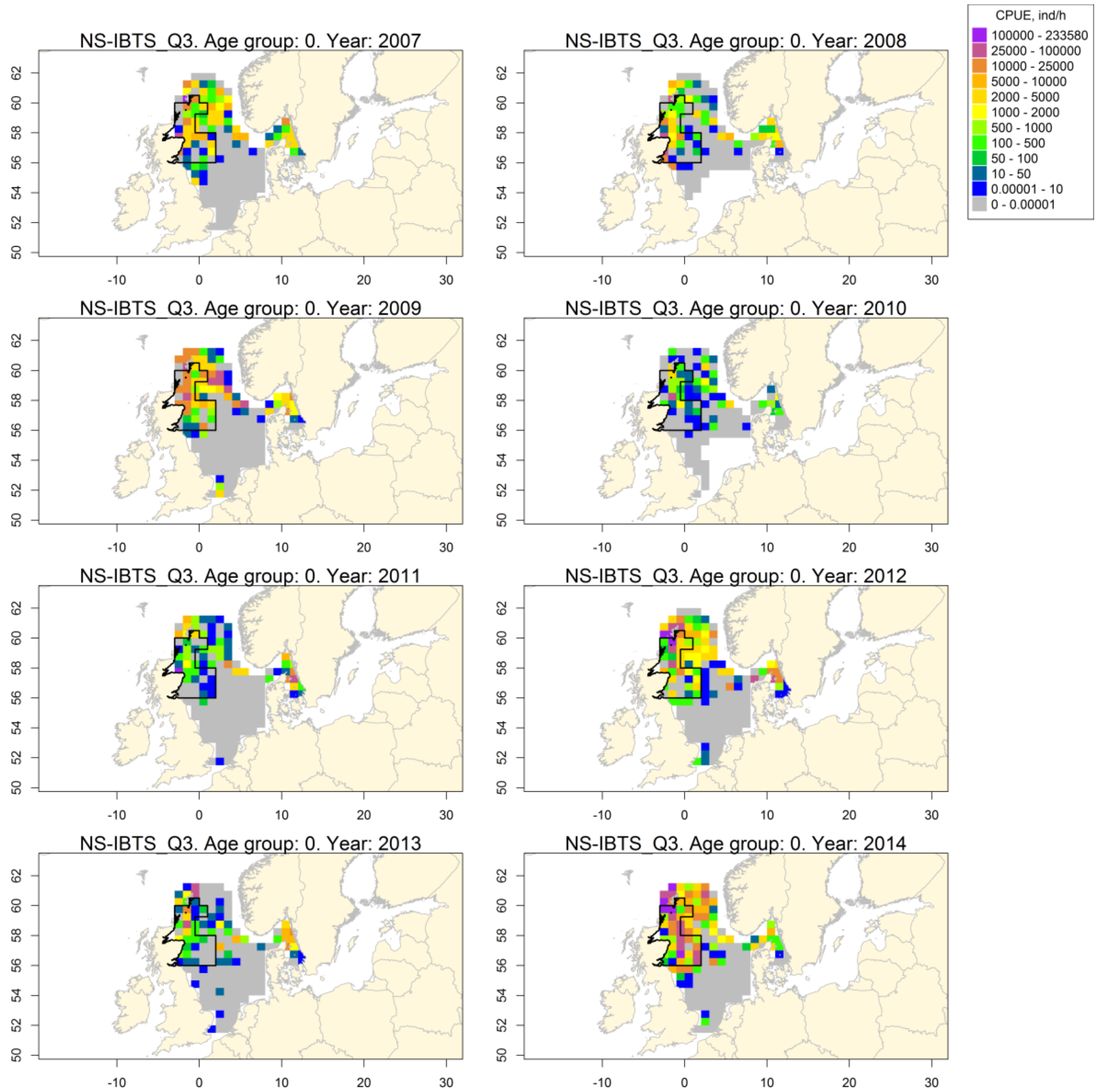

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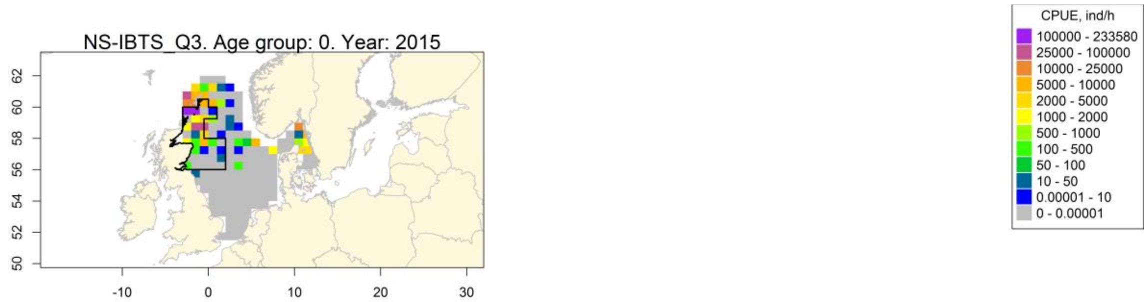

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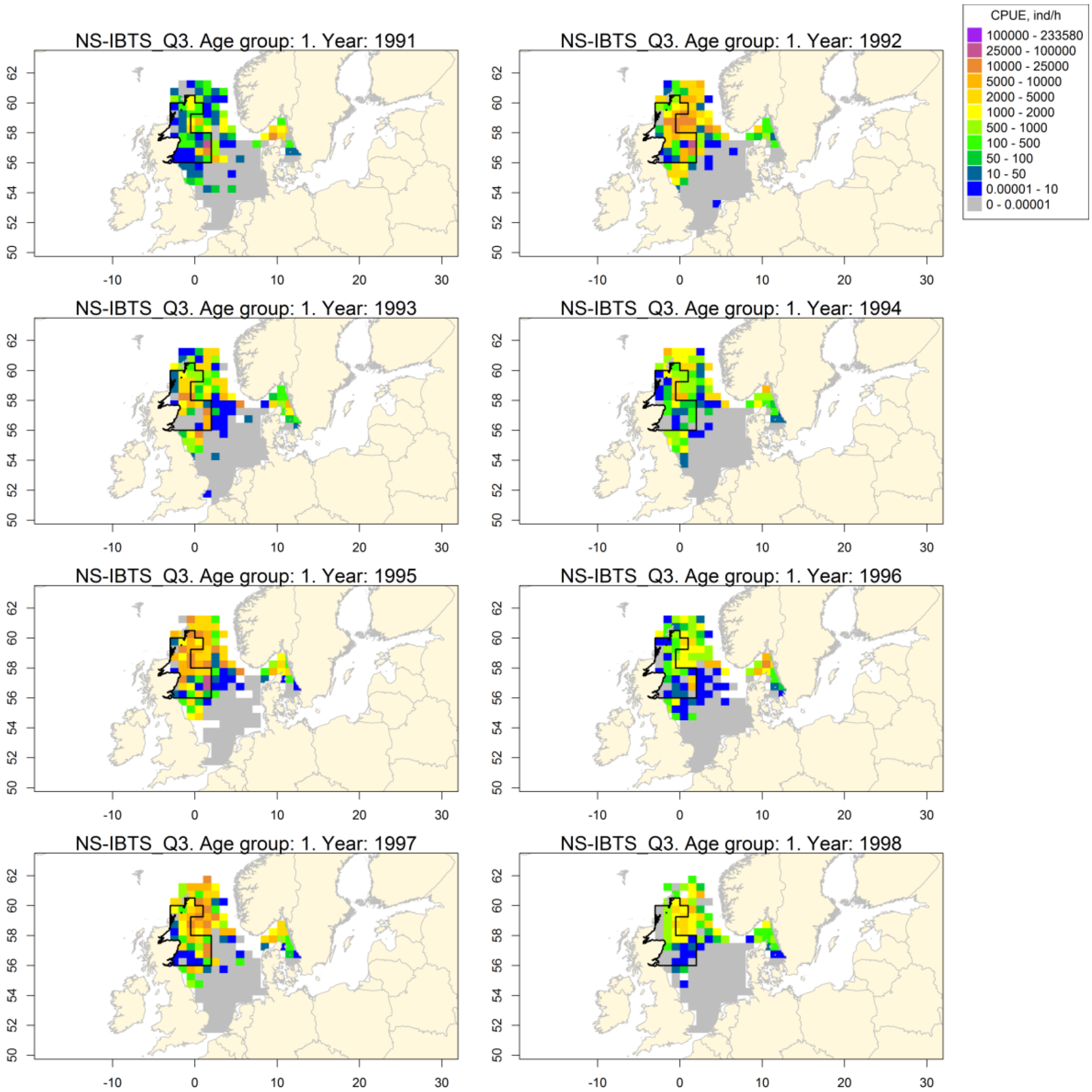

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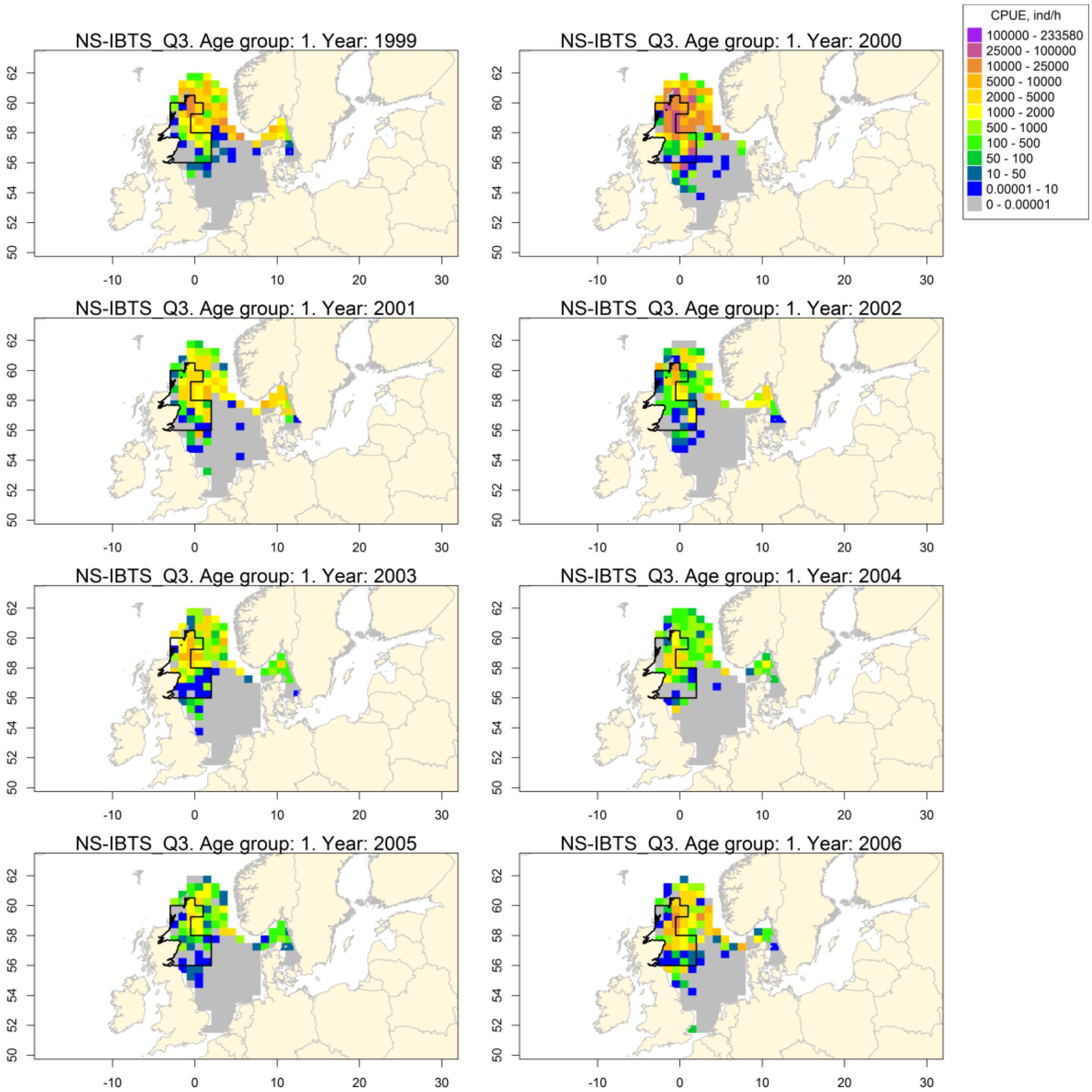

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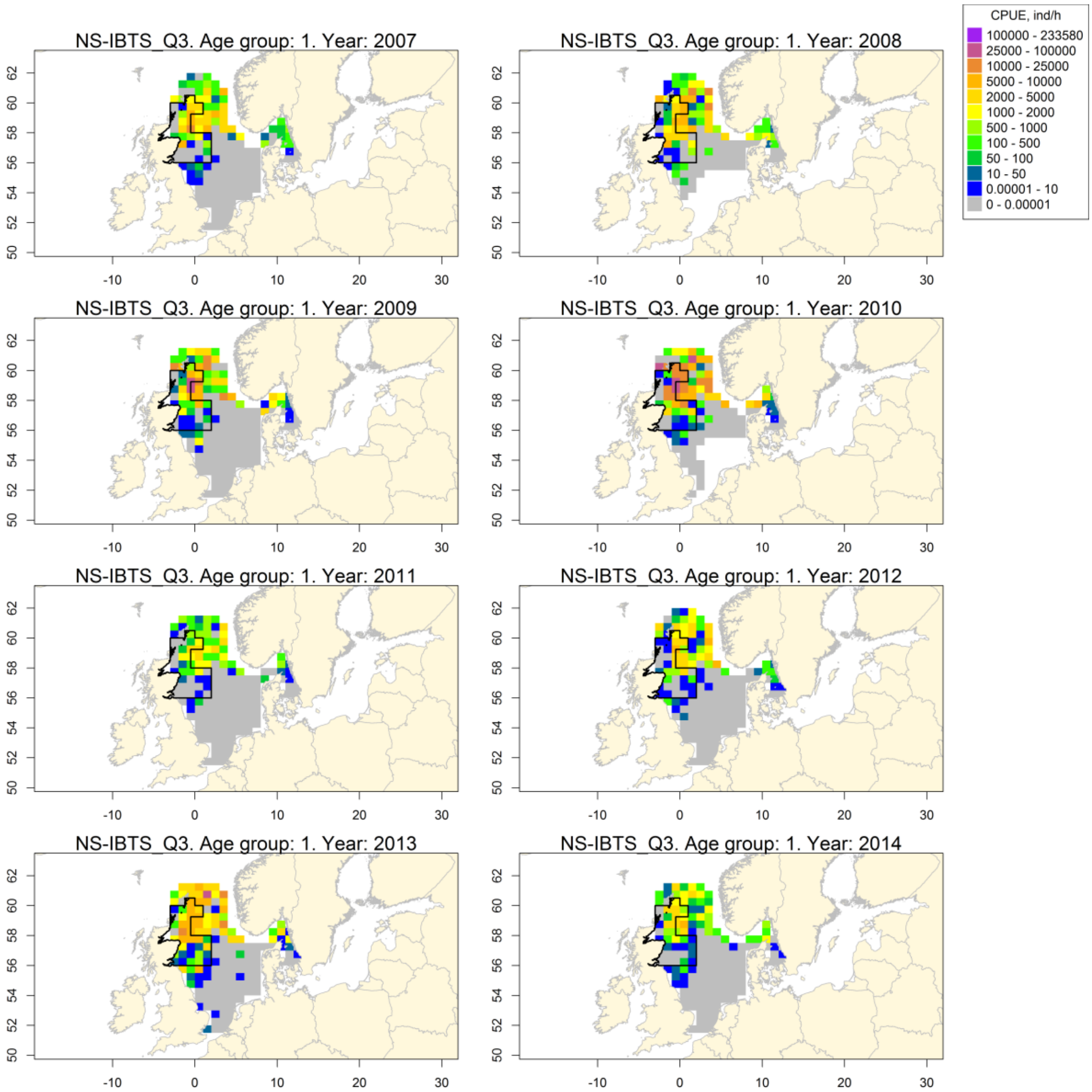

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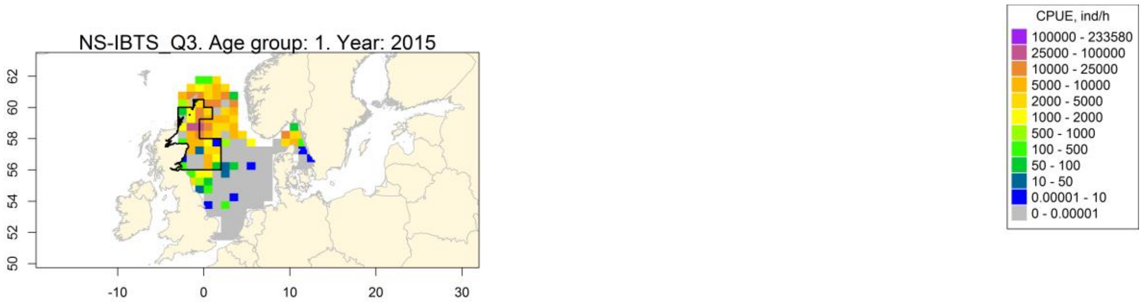

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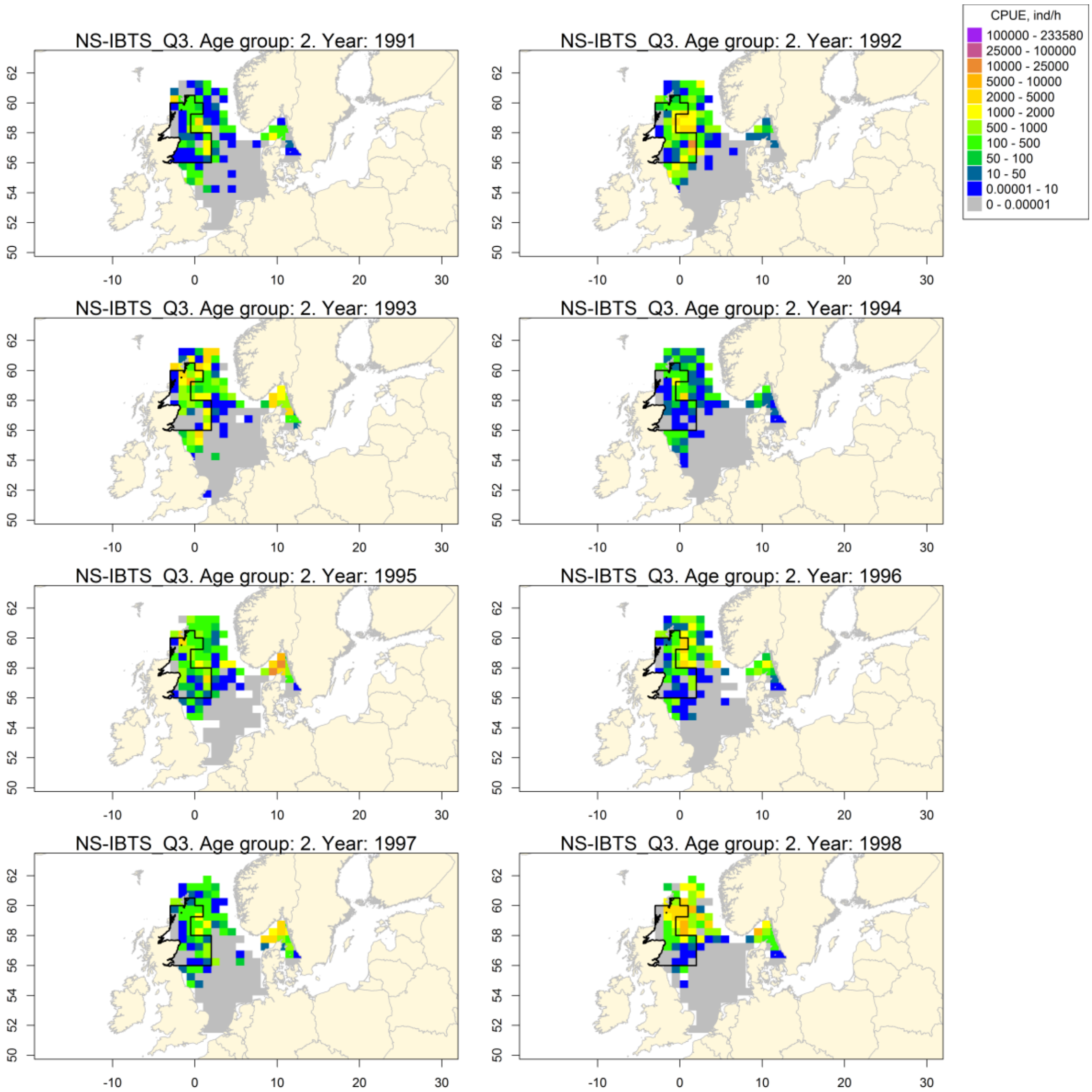

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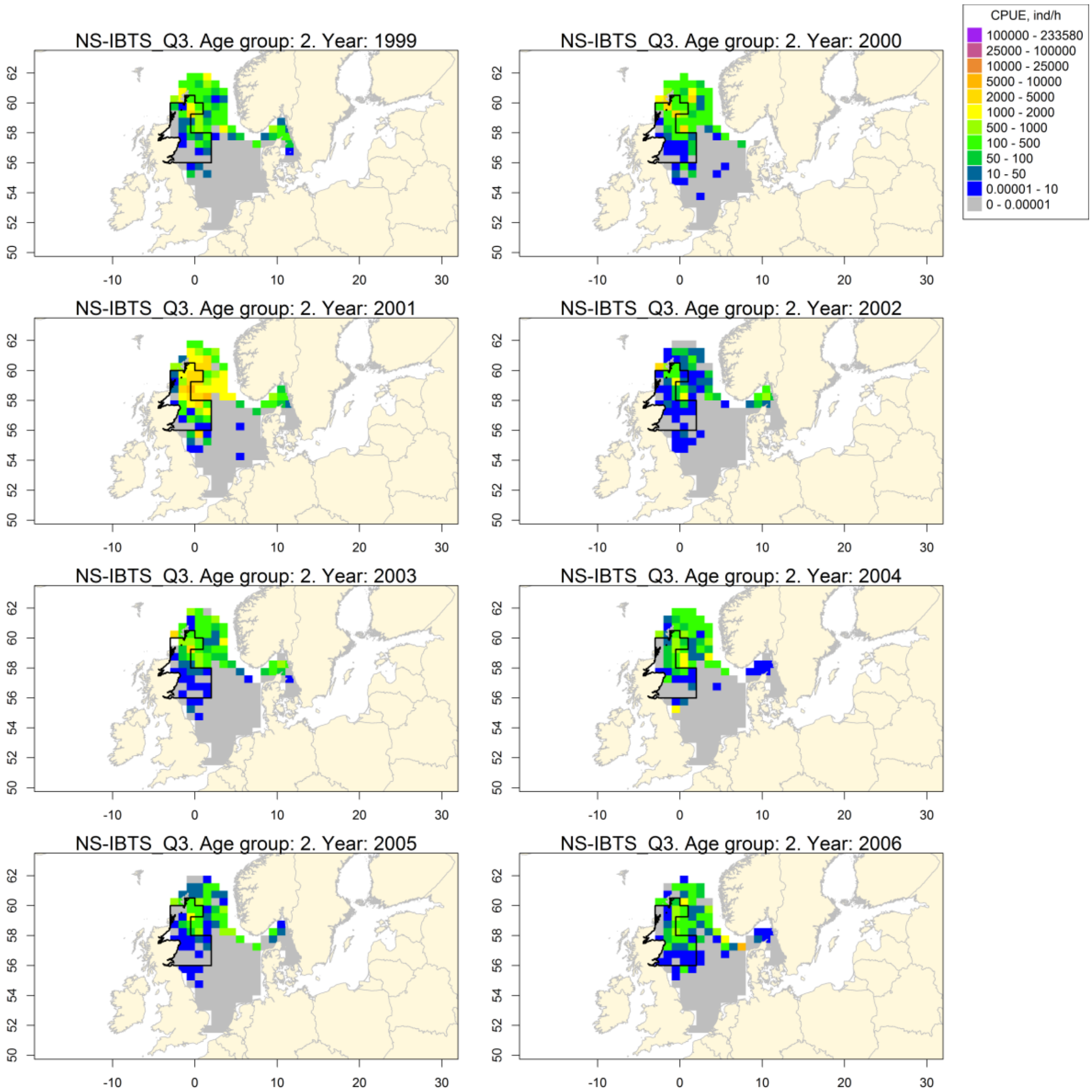

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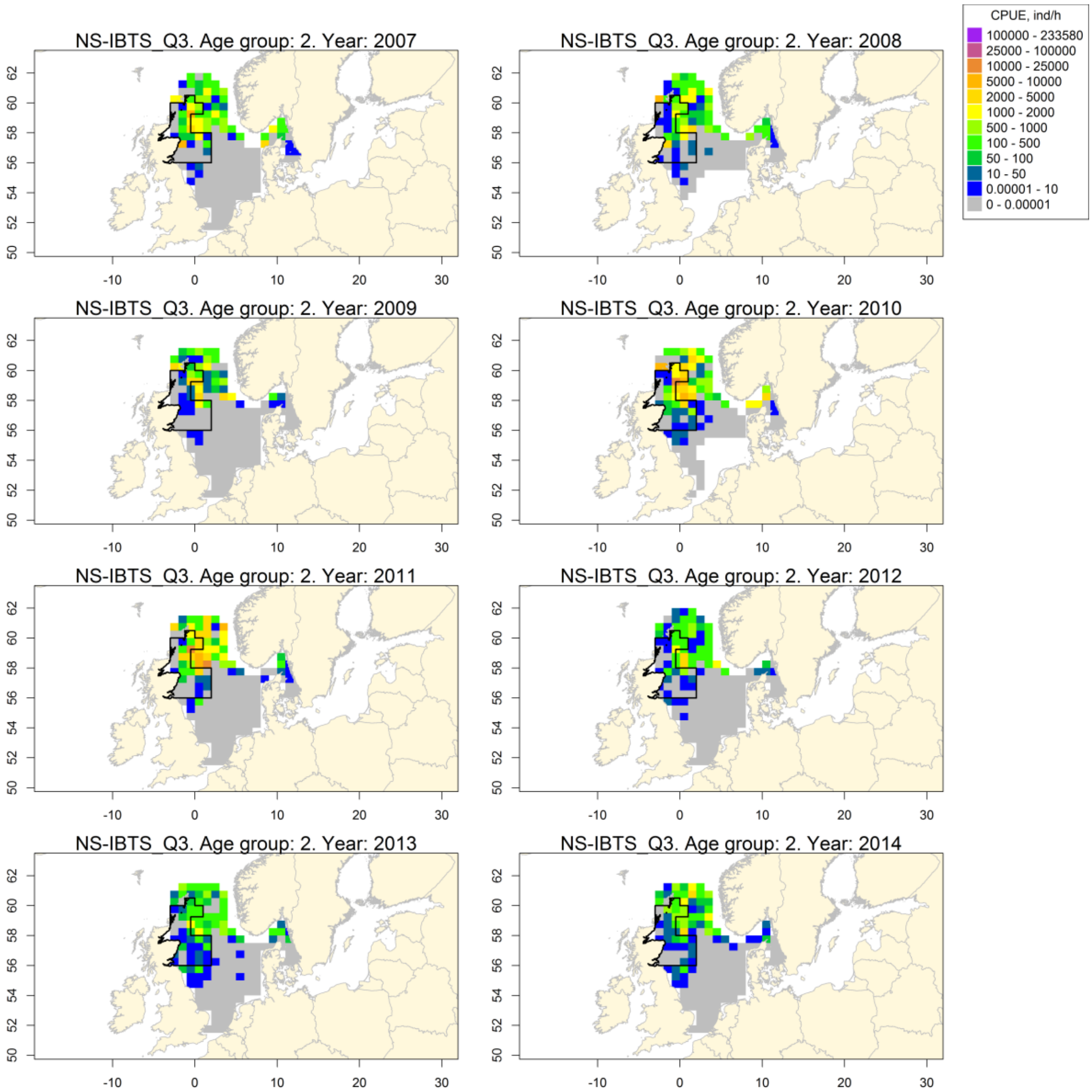

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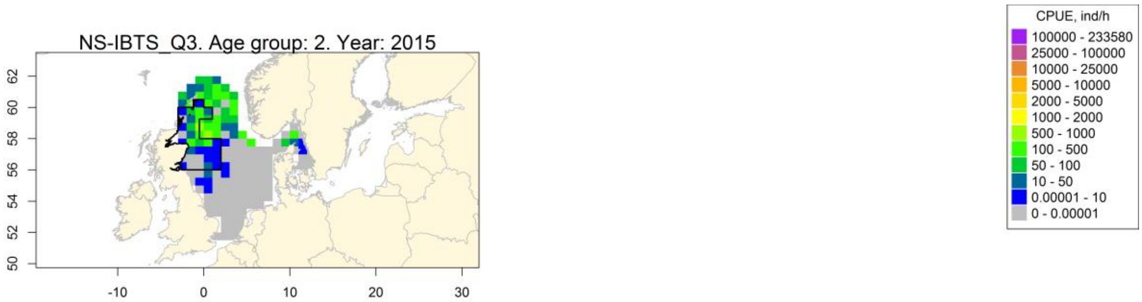

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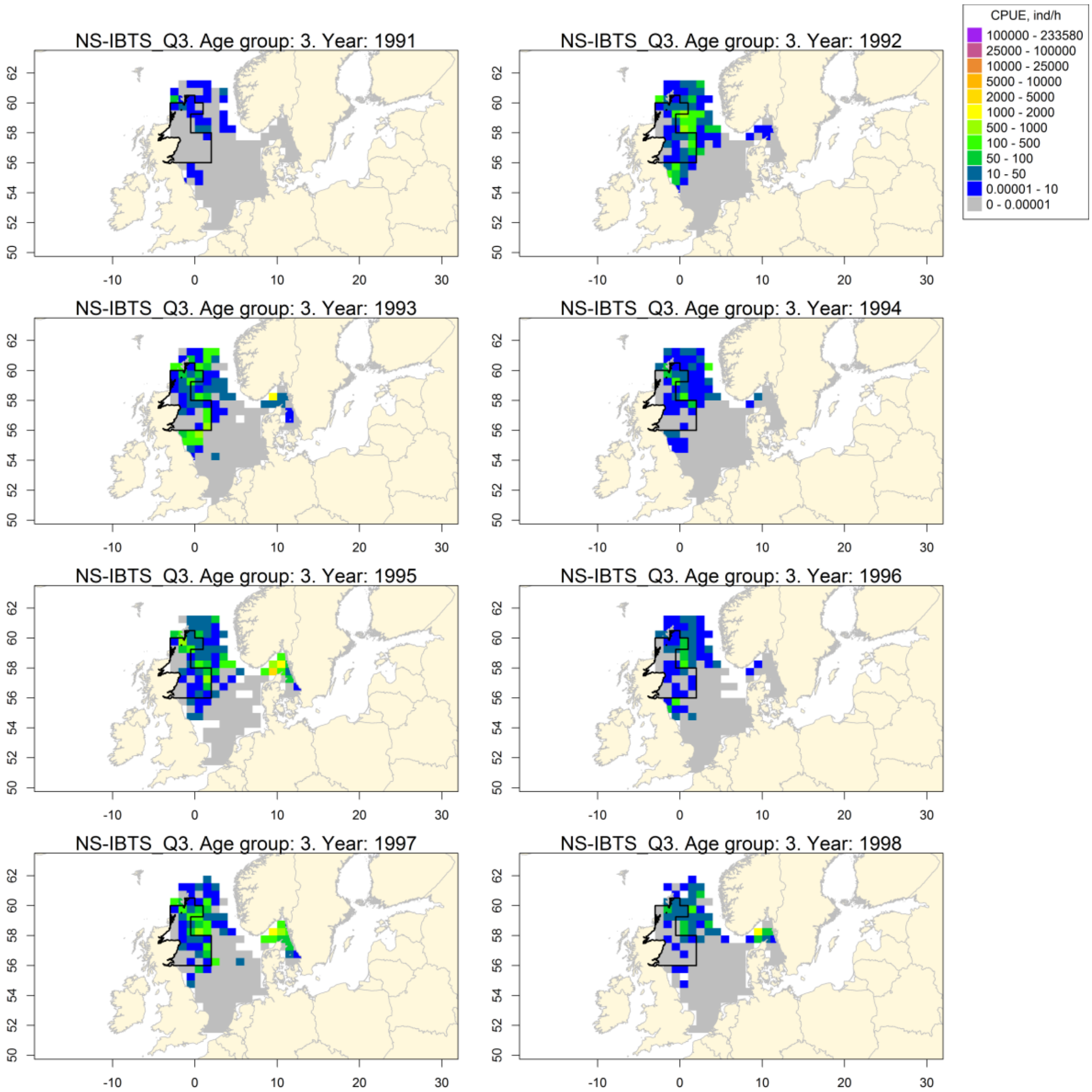

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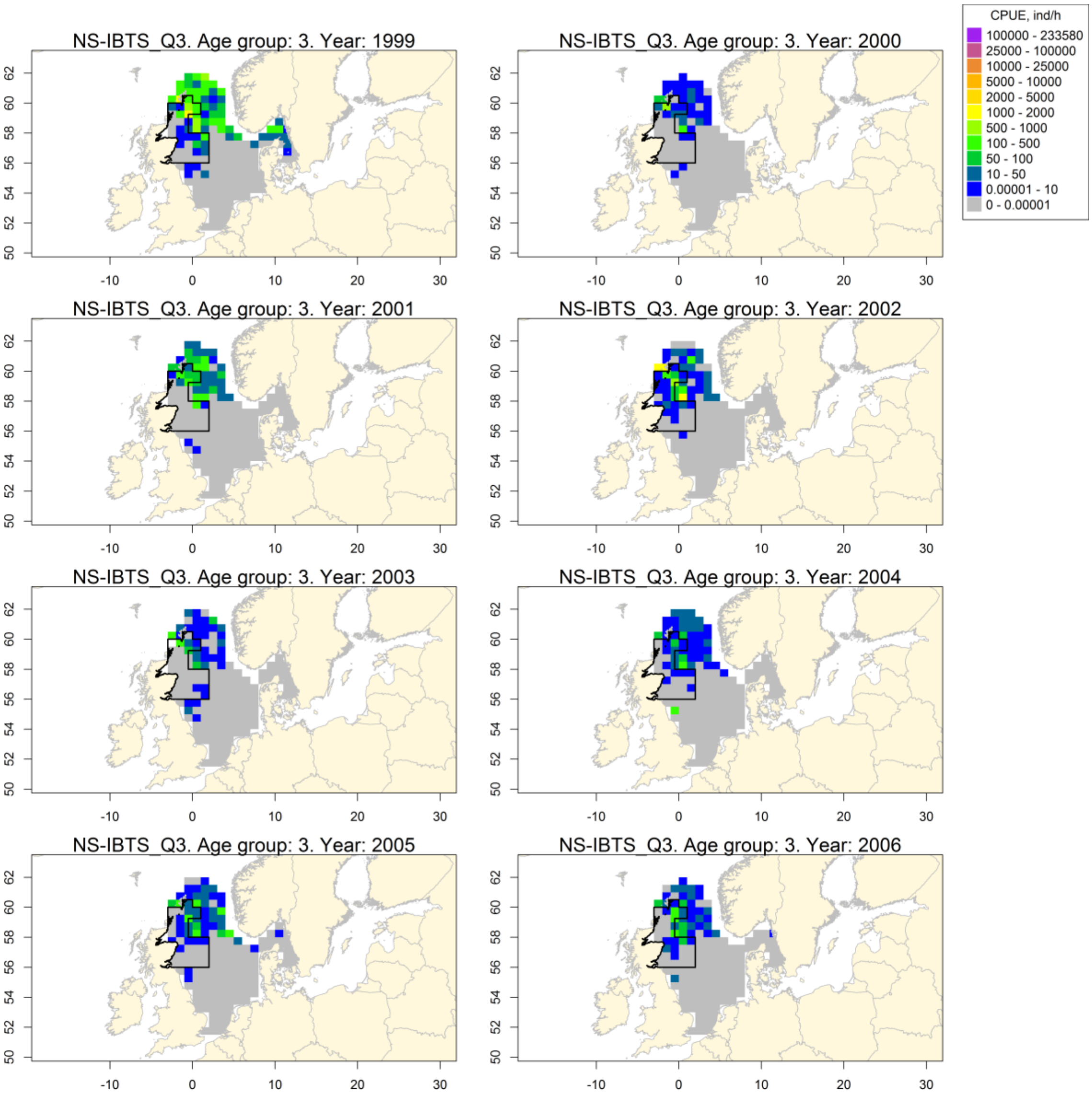

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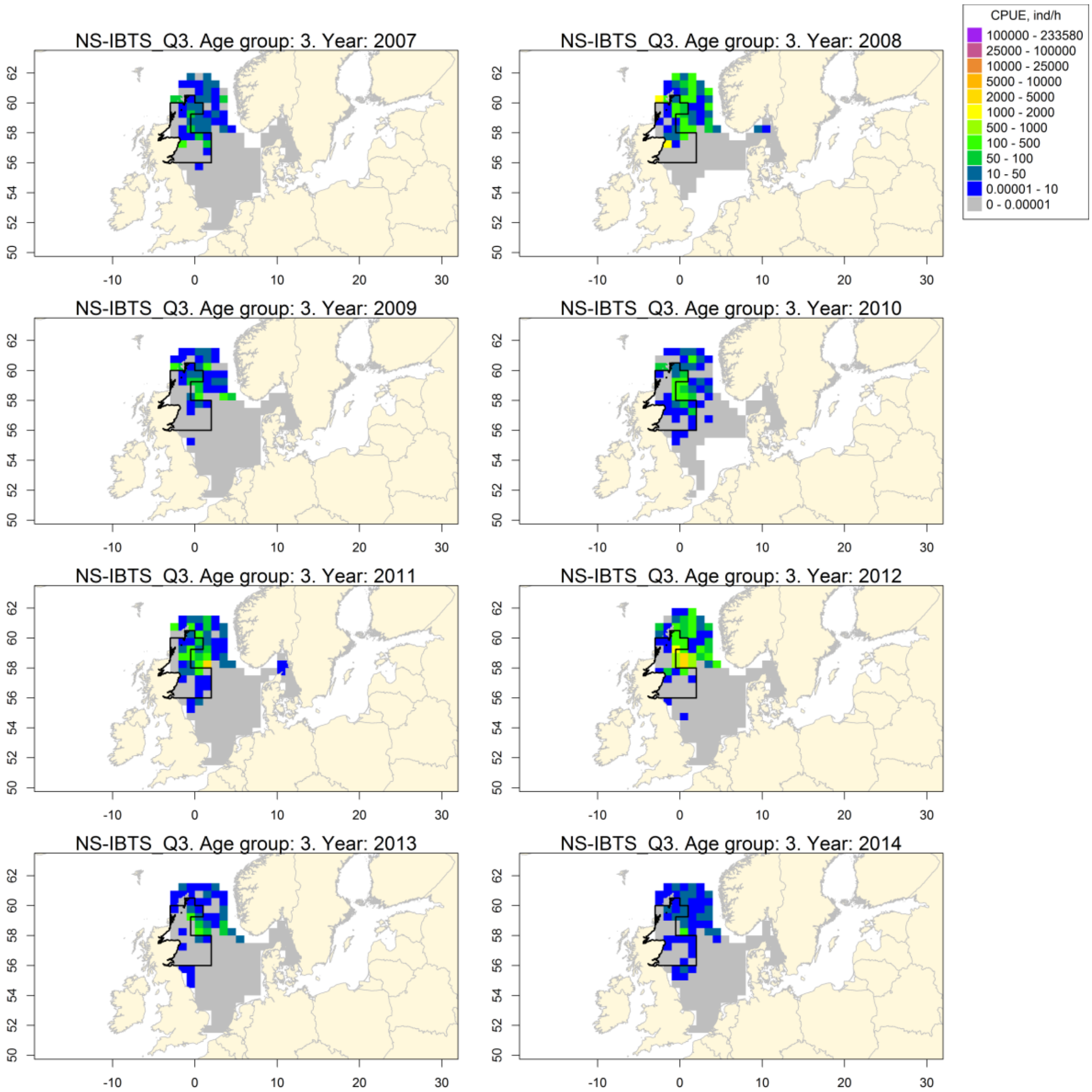

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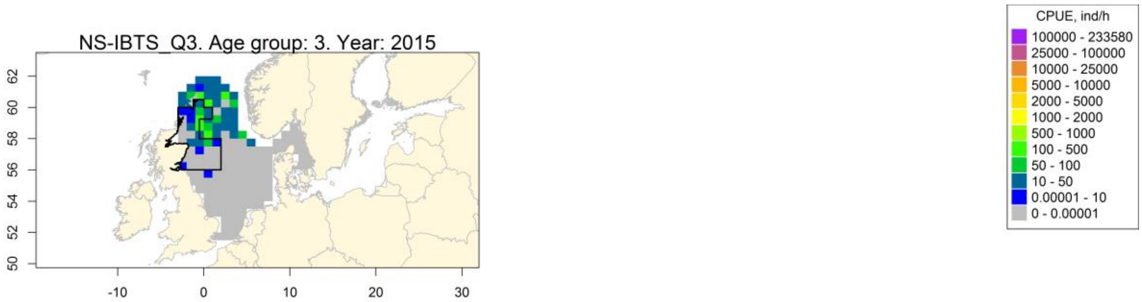

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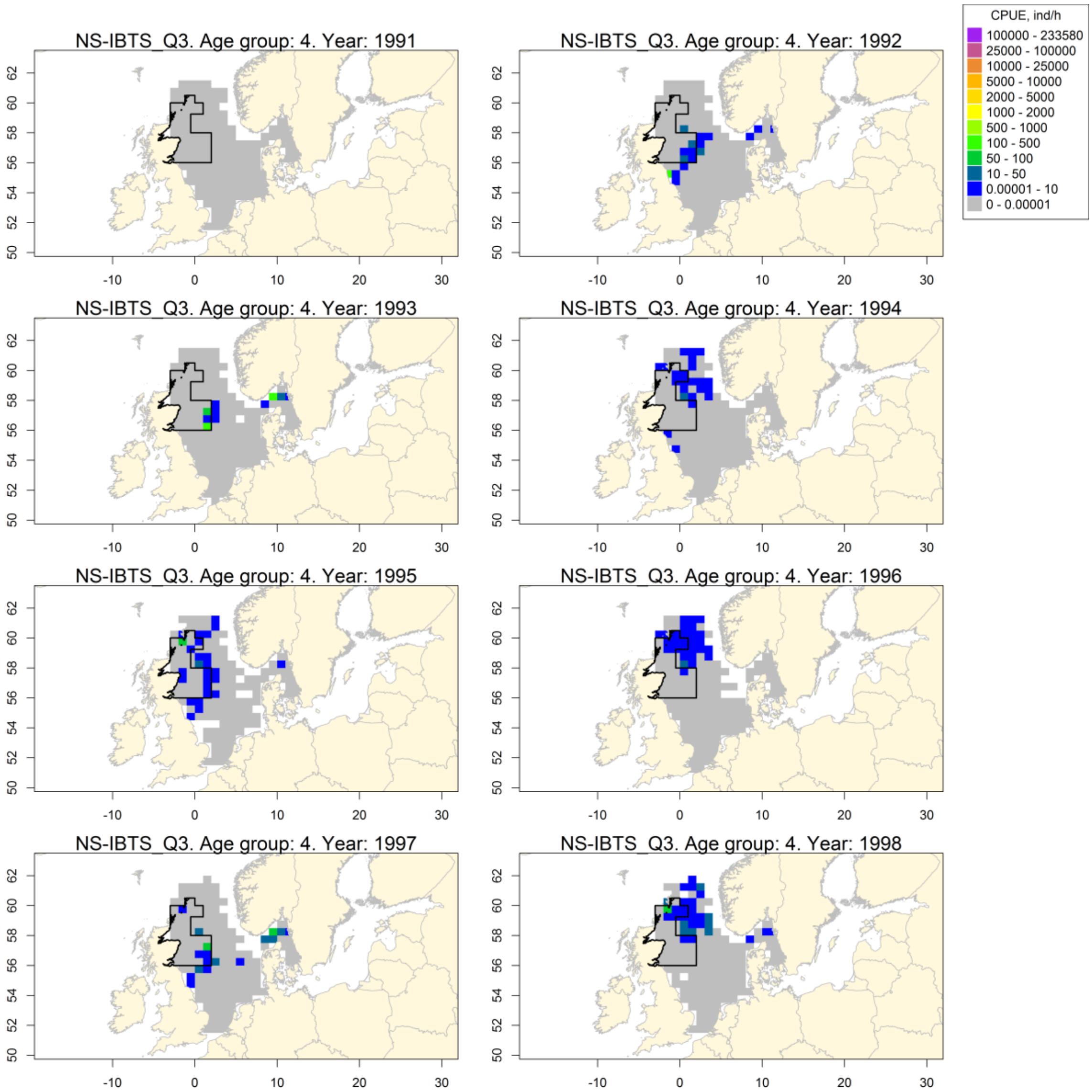

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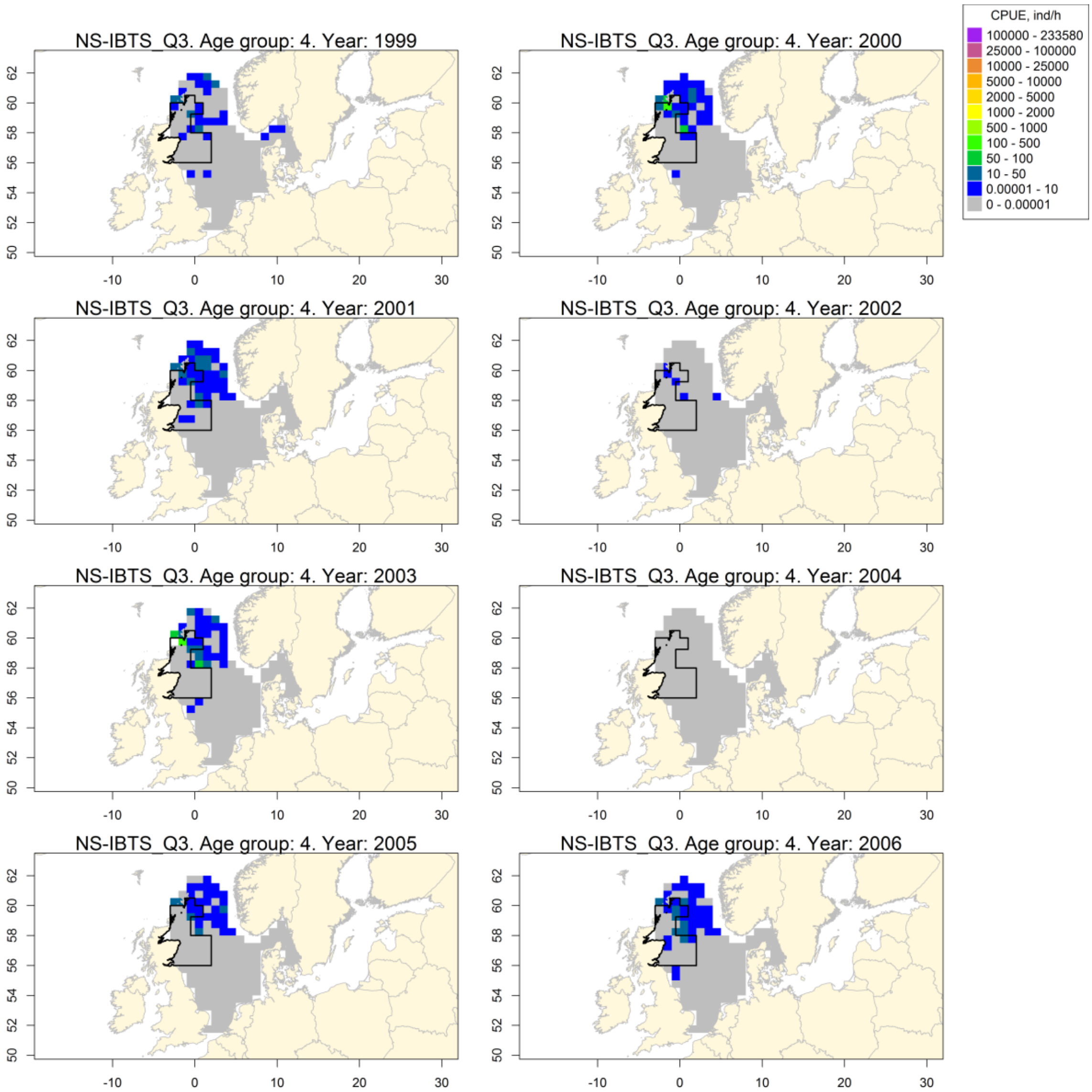

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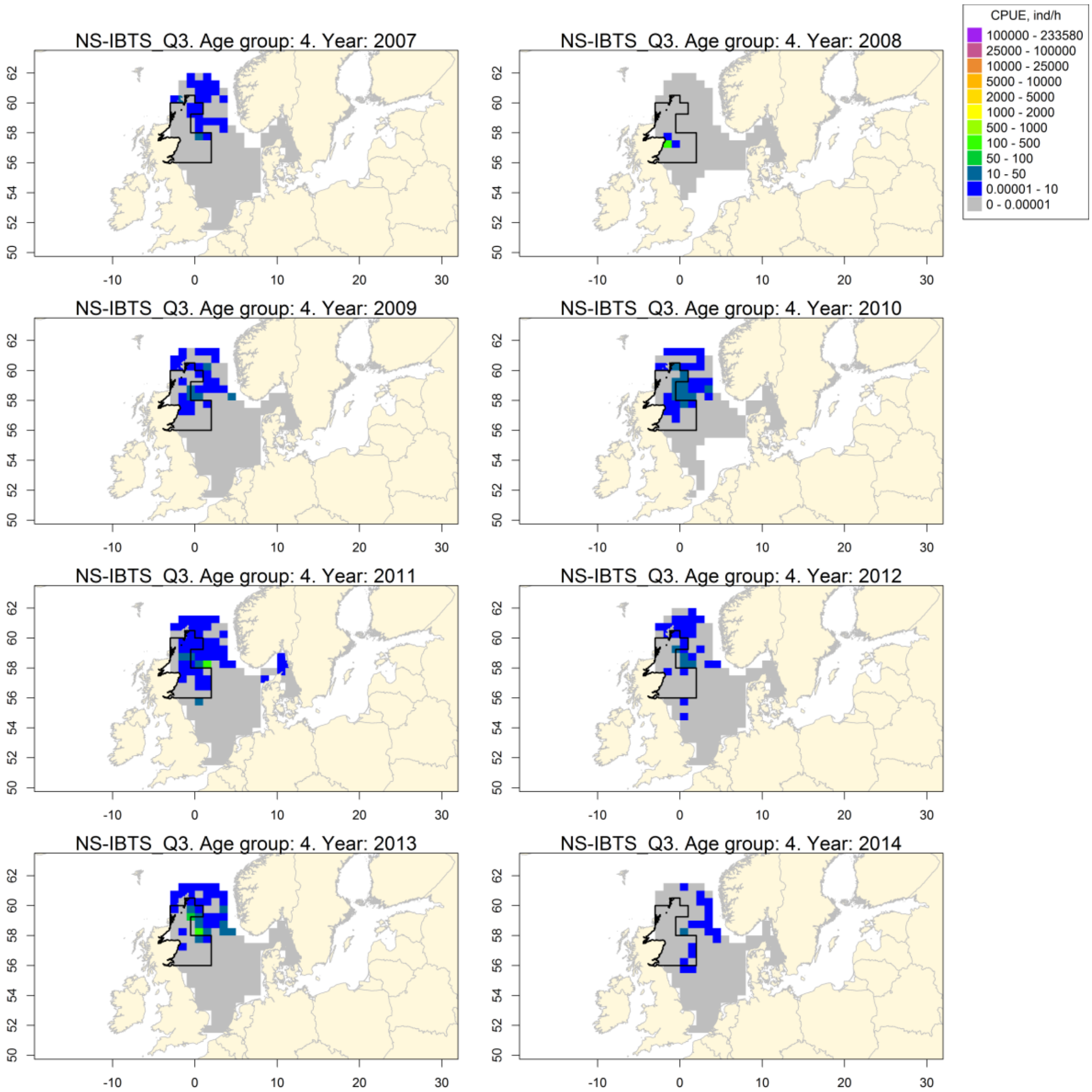

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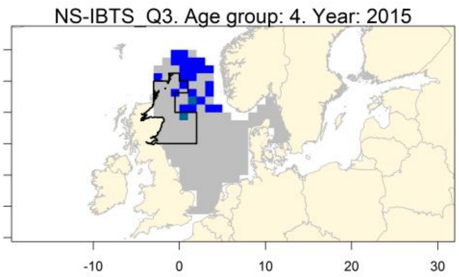

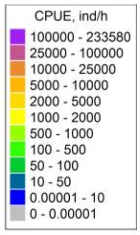

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Danish Norway pout fishery in the North Sea and Skagerrak

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Introduction

This working document presents the Danish Norway pout fishery in the North Sea and Skagerrak (ICES Area IV and IIIa), nop34, relevant for the ICES benchmark assessment for the stock in August 2016, ICES WKPOUT.

The working document is subdivided into 3 main sections with different ecosystem aspects and considerations.

1. The Danish Norway pout fishery and its distribution
   - A1. International targeted Norway pout fishery with focus on Danish fishery
   - A2. Distribution of the Danish targeted Norway pout fishery
   - A3. Sampling of the Danish Targeted Norway pout fishery
   - A4. By-catches in the Norway pout fishery and gear selectivity
   - A5. Discard of Norway pout in fisheries for consume purposes
   - A6. Commercial fishery efficiency by year, quarter, metier and vessel category
   - A.7 Commercial catch and effort fishery data used in the assessment up to 2016
2. Distribution of the Norway pout stock in relation to the fishery
   - B1. Distribution of the stock in relation to the fishery based on survey data and survey tuning time series used in the assessment
3. Relevant fishery regulations for the Norway pout fishery
4. Quota up-take in the Norway pout fishery
5. Mean weight at ages used in the catch and in the commercial tuning fleet

1. The Danish Norway pout fishery and its distribution

A.1. International targeted Norway pout Fishery with focus on Danish Fishery

The Norway pout fishery is a mixed commercial, small meshed fishery. Norway pout is caught in small meshed trawls (16-31 mm) in a mixed fishery among other with blue whiting, i.e. in addition to the directed Norway pout fishery by Denmark and Norway, the species is also taken as by-catch in the Norwegian blue whiting fishery. Norway pout is landed for reduction purposes (fish meal and fish oil).

During the 1960s a significant small-mesh fishery developed for Norway pout in the northern North Sea. The fishery is nearly exclusively carried out by Danish and Norwegian (large) vessels using small-mesh trawls in the north-western North Sea especially at the Fladen Ground and along the edge of the Norwegian Trench in the north-eastern part of the North Sea (**Tables 1-2; Figures 1-2 DK fishery; Figure 3 DK+N fishery**). Main fishing seasons are 3rd and 4th quarters of the year with also some catches in 1st quarter of the year especially previous to 2002 (**Tables 3-4**). The quarterly spatial distribution of the Norway pout catches for the Danish small meshed fishery for reduction purposes is shown in **Figure 4** during a twenty year period from 1987-2015, and in **Figure 5** as a quarterly average during a ten year period from 1994-2003 for the combined Danish and Norwegian fishery. An overview of quarterly landings for the period 1989-2014 is given for the Danish small meshed fishery for reduction purposes in **Figure 6,** and for the combined Danish and Norwegian small meshed fisheries in **Figure 7**.

The fishery in more recent times is mainly carried out by Denmark and Norway at fishing grounds in the northern North Sea especially at Fladen Ground and along the edge of the Norwegian Trench. The share of the catches between Denmark and Norway varies over time, sometimes Denmark have the major yearly catches, sometimes Norway, without any trends over time. The long term average show rather equal catches between the two countries. There is a tendency towards the more recent Danish landings mainly originates from the Fladen Ground area compared to the Norwegian Trench area.

The total international landings have been lower (well below 100 kt per year) since 2001 compared to previous landings well above 100 kt per year (**Tables 1-4**). The landings in 2010 and 2013 were above and close to 100 kt, respectively, because of the strong 2009 and 2012 year classes. Landings in 2015 were also high because of the very strong 2014 year class. The 2003-2004 landings were the lowest on record, and also effort in 2003 and 2004 were historically low and well below the average of the 5 previous years. The targeted Norway pout fishery was closed in 2005, in the first half year of 2006, all of 2007, and during the first half year 2011 and 2012. In the periods of closures there have in some years been set by-catch quotas for Norway pout in the Norwegian mixed blue whiting fishery, as well as in a small experimental fishery in 2007. The fishery was open for the second half year of 2006 and in all of 2008 to 2010 based on the strong 2007-2009 year classes being around or above the long term average level. However, the Norwegian part of the Norway pout fishery was only open from May to August in 2008 during that year. In the open periods of 2008, 2009, and 2011 the fishing effort and catches have been low, but have been at higher level in 2010, 2012, 2013, 2014 and 2015. The fishery has in these periods mainly been based on the 2008, 2009, 2012 and 2014 year classes being around or above the long term average level.

A.2. Distribution of the Danish Targeted Norway pout Fishery

Below is given the total landings of Norway pout by year and country as well as the distribution of the Danish commercial industrial fishery landings (=catches) of Norway pout using the species distribution in all industrial fishery by Denmark obtained from the described standardized Danish samplings of the small meshed fisheries for reduction purposes in **Section A.3**. Accordingly, the landings include all Danish small meshed fishery for reduction purposes where Norway pout is caught including by-catches of Norway pout in other industrial fishery targeting e.g. sprat and sandeel, i.e. not only landings where Norway pout has been among the target species in the small meshed fisheries. The tabulated landings originates from the last accepted Norway pout assessment in September 2015 from the ICES WGNSSK Report 2015. Consequently, only landings up to 3rd quarter 2015 are included in the Tables. The landings distributions in the **Figures 1,2, 4, 7 and 8** below originates from data extracted from relevant databases in Summer 2016 after completion of the data call for the Norway pout benchmark assessment in August 2016 and, accordingly, includes data for all of 2015 as well as previous years.

The yearly distributions are given in **Figure 1** and the quarterly distribution is given in **Figure 4** of the Danish Norway pout landings (=catches) in the small meshed fishery for reduction purposes during a twenty year period from 1987-2015. The quarterly distributions of the landings are also given by fishery (= metier) in **Figure 4**. The final part of **Figure 4** shows the average landings by metier for the period 2004-2015 in the Danish small meshed fishery targeting Norway pout for respectively the North Sea and the Skagerrak-Kattegat areas. It should be noted here that the overall dominant metiérs in the Danish small meshed fishery targeting Norway pout up to 2012 is bottom otterboard trawlers for demersal fish fishing with mesh-sizes 16-31 mm in the trawl cod-end (OTB_DEF_16-31_0_0 metiér) without selective grids, and from 2012 onwards the same fishery fishing with a selective grid mounted in front of the cod-end in the trawl and with a bar width of 35 mm, which became mandatory to use for all vessels targeting Norway pout according to regulations implemented from the 15th October 2012 onwards (OTB_DEF_16-31_2_35 metiér) – see also under regulations in **Section 3**. The **Figure 5** shows the quarterly average landings during a ten year period from 1994-2003 for the combined Danish and Norwegian fishery, while there in **Figure 6** is given an overview of the quarterly landings by year for the period 1989-2014 for the Danish small meshed fishery for reduction purposes, and in **Figure 7** the quarterly landings by year for the same period for the combined Danish and Norwegian fisheries. The distribution of fishing power and catch efficiency of different vessel groups (as a comparison between those) is shown in **Figure 8**. This is presented as catch rates (ton/fishing day) for the small meshed Danish industrial fishery for of Norway pout by year, quarter, ICES rectangles, metier, and engine horse power class for the period 1987-2015.

The Danish metiérs catching Norway pout covers small meshed bottom otterboard trawlers for demersal fish which are used for reduction purposes (OTB_DEF_<16_0_0, OTB_DEF_16-31_0_0, OTB_DEF_16-31_2_35), midwater pair trawlers fishing small pelagic fish such as sprat (PTM_SPF_16-31_0_0; PTM_SPF_32-69_0_0), small meshed bottom otterboard trawlers fishing shrimp (crustaceans) for consume purposes (OTB_CRU_32-69_0_0) or for small pelagic fish (OTB_SPF_<16_0_0, OTB_SPF_16-31_0_0, OTB_SPF_16-31_2_35), or to less extent for mixed crustaceans (Nephrops) and demersal fish (OTB_MCD_90-119_0_0, OTB_MCD_>=120_0_0), bottom pair trawlers fishing for small pelagic fish (PTB_SPF_32-69_0_0), small meshed midwater otterboard trawlers fishing for small pelagic fish (OTM_SPF_16-31_0_0) and very seldom anchored seine fishery for demersal fish (SDN_ DEF_90-119_0_0).

The main engine horse power categories for the fishing vessels used are the following main engine categories: 0-500 hp, 500-1000 hp, 1000-1500 hp, 1500-2000 hp, >= 2000 hp.

Table 1 NORWAY POUT IV & IIIa. Nominal landings (‘000 tonnes) from the North Sea and Skagerrak / Kattegat, ICES areas IV and IIIa in the period 2003-2014, as officially reported to ICES and EU. By-catches of Norway pout in other (small meshed) fishery included.

Norway pout ICES area IIIa

Country	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Denmark	110	-	18	24	156	-	51	2	118	6.945	538 *
Faroe Islands	45	-	-	-	-	-	-	-	-	-	-
Norway	41	-	2	-	-	209	711	-	-	147	9 *
Sweden	-	-	-	-	-	-	10	-	-	1	1 *
Germany	54	-	-	-	4	-	-	-	-	-	-
Total	250	0	20	24	160	209	772	2	118	7.093	548

*Preliminary.

Norway pout ICES area IVa

Country	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Denmark	10.762	941***	39.531	59	32.158	19.226	71.032	4.038	24.829 *	31.376	27.894 *
Faroe Islands	1.085	24	-	-	-	-	-	-	-	-	-
Netherlands	-	-	-	-	-	22	18	-	-	-	-
Germany	-	-	15	-	-	-	-	-	-	-	-
Norway	4.953	311	13.618	4.712	6.650	36.961	64.303	3.189	4.528 *	46.187	18.725 *
Sweden	-	-	-	-	10	-	+	1	3 *	4	1 *
UK(Scotland)	-	-	-	-	-	-	29	-	6 *	-	8 *
Total	16.800	1.092	53.164	4.771	38.818	56.209	135.353	7.228	29.360	77.567	46.620

*Preliminary.

Norway pout ICES area IVb

Country	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Denmark	473	-	394	-	244	595	229	32	611 *	43	16 *
Faroe Islands	29	-	-	-	-	-	-	-	-	-	-
Germany	-	-	19	-	-	75	-	-	-	-	-
Netherlands	-	-	-	-	-	-	-	-	-	-	-
Norway	-	-	2	-	-	82	620	21	59 *	615	8 *
Sweden	88	-	-	-	-	-	-	-	-	0	0 *
UK (E/W/NI)	-	-	-	-	-	-	-	-	-	-	-
UK (Scotland)	-	-	-	-	-	-	-	-	-	-	6 *
Total	590	0	415	0	244	752	849	53	670	658	30

*Preliminary.

Norway pout ICES area IVc

Country	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Denmark	-	-	-	-	-	-	-	-	-	-	-
France	-	-	-	+	+	-	-	-	-	-	-
Netherlands	-	-	-	-	-	-	-	-	-	-	-
UK (E/W/NI)	-	-	-	-	-	-	-	-	-	-	-
Total	0	0	0	0	0	0	0	0	0	0	0

*Preliminary.

Norway pout Sub-area IV and IIIa (Skagerrak) combined

Country	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Denmark	11.345	941***	39.943	83	32.558	19.821	71.312	4.072	25.558	38.364	28.448
Faroe Islands	1.159	24	0	0	0	0	0	0	0	0	0
Norway	4.994	311	13.622	4.712	6.650	37.252	65.634	3.210	4.587	46.949	18.742
Sweden	88	0	0	0	10	0	10	1	3	5	2
Netherlands	0	0	0	0	0	22	18	0	0	0	0
Germany	54	0	34	0	4	75	0	0	0	0	0
UK	0	0	0	0	0	0	0	0	0	0	6
Total nominal landings	17.640	1.252	53.599	4.795	39.222	57.170	136.974	7.283	30.148	85.318	47.198
By-catch of other species and other	-4.140	-	-6.973	-	-3.084	-2.670	-11.019	-759	-3.075	-3.218	-3.028
ICES estimate of total landings (IV+IIIaN	13.500	-	46.626	-	36.138	54.500	125.955	6.524	27.073	82.100	44.170
Agreed TAC	198.000	0****	95.000	0****	114.616 x	116.279 x	162.950 x	4.500 x	70.683 x	167.500 x	128.250 x

* provisional / preliminary
** provisional / preliminary
*** 781 ton from trial fishery (directed fishery); 160 ton from by-catches in other fisheries
**** A by-catch qouta of 5000 t has been set.
***** 681 t taken in trial fishery; 1300 t in by-catches in other (small meshed) fisheries.
+ Landings less than 1
n/a not available
x EU TAC

Table 2 NORWAY POUT IV & IIIa. Annual landings ('000 t) in the North Sea and Skagerrak (not incl. Kattegat, IIIaS) by country, for 1961-2014 (Data provided by ICES WGNSSK Working Group members). (Norwegian landing data include landings of by-catch of other species). Includes by-catch of Norway pout in other (small meshed) fisheries).

Year	Denmark		Faroes	Norway	Sweden	UK (Scotland)	Others	Total
	North Sea	Skagerrak						
1961	20,5	-	-	8,1	-	-	-	28,6
1962	121,8	-	-	27,9	-	-	-	149,7
1963	67,4	-	-	70,4	-	-	-	137,8
1964	10,4	-	-	51	-	-	-	61,4
1965	8,2	-	-	35	-	-	-	43,2
1966	35,2	-	-	17,8	-	-	+	53,0
1967	169,6	-	-	12,9	-	-	+	182,5
1968	410,8	-	-	40,9	-	-	+	451,7
1969	52,5	-	19,6	41,4	-	-	+	113,5
1970	142,1	-	32	63,5	-	0,2	0,2	238,0
1971	178,5	-	47,2	79,3	-	0,1	0,2	305,3
1972	259,6	-	56,8	120,5	6,8	0,9	0,2	444,8
1973	215,2	-	51,2	63	2,9	13	0,6	345,9
1974	464,5	-	85,0	154,2	2,1	26,7	3,3	735,8
1975	251,2	-	63,6	218,9	2,3	22,7	1	559,7
1976	244,9	-	64,6	108,9	+	17,3	1,7	437,4
1977	232,2	-	48,8	98,3	2,9	4,6	1	387,8
1978	163,4	-	18,5	80,8	0,7	5,5	-	268,9
1979	219,9	9	21,9	75,4	-	3	-	329,2
1980	366,2	11,6	34,1	70,2	-	0,6	-	482,7
1981	167,5	2,8	16,4	51,6	-	+	-	238,3
1982	256,3	35,6	12,3	88	-	-	-	392,2
1983	301,1	28,5	30,7	97,3	-	+	-	457,6
1984	251,9	38,1	19,11	83,8	-	0,1	-	393,01
1985	163,7	8,6	9,9	22,8	-	0,1	-	205,1
1986	146,3	4	2,5	21,5	-	-	-	174,3
1987	108,3	2,1	4,8	34,1	-	-	-	149,3
1988	79	7,9	1,3	21,1	-	-	-	109,3
1989	95,7	4,2	0,8	65,3	+	0,1	0,3	166,4
1990	61,5	23,8	0,9	77,1	+	-	-	163,3
1991	85	32	1,3	68,3	+	-	+	186,6
1992	146,9	41,7	2,6	105,5	+	-	0,1	296,8
1993	97,3	6,7	2,4	76,7	-	-	+	183,1
1994	97,9	6,3	3,6	74,2	-	-	+	182
1995	138,1	46,4	8,9	43,1	0,1	+	0,2	236,8
1996	74,3	33,8	7,6	47,8	0,2	0,1	+	163,8
1997	94,2	29,3	7,0	39,1	+	+	0,1	169,7
1998	39,8	13,2	4,7	22,1	-	-	+	57,7
1999	41	6,8	2,5	44,2	+	-	-	94,5
2000	127	9,3	-	48	0,1	-	+	184,4
2001	40,6	7,5	-	16,8	0,7	+	+	65,6
2002	50,2	2,8	3,4	23,6	-	-	-	80,0
2003	9,9	3,4	2,4	11,4	-	-	-	27,1
2004	8,1	0,3	-	5	-	-	0,1	13,5
2005	0.9*	-	-	1	-	-	-	1,9
2006	35,1	0,1	-	11,4	-	-	-	46,6
2007	2.0**	-	-	3,7	-	-	-	5,7
2008	30,4	-	-	5,7	+	-	+	36,1
2009	17,5	-	-	37,0	+	-	+	54,5
2010	64,9	0,2	-	60,9	+	+	+	126,0
2011	3,3	-	-	3,2	+	+	+	6,5
2012	22,3	0,1	-	4,6	+	+	+	27,0
2013	29,0	6,2	-	46,9	+	+	+	82,1
2014	25,0	0,5	-	18,7	+	+	+	44,2

* 781 t taken in a trial fishery; 160 t in by-catches in other (small meshed) fisheries.

** 681 t taken in trial fishery; 1300 t in by-catches in other (small meshed) fisheries.

Table 3 NORWAY POUT IV & IIIa. National landings (‘000 tonnes) by quarter of year 1997-2015. (Data provided by Working Group members. Norwegian landing data include landings of by-catch of other species). (By-catch of Norway pout in other (small meshed) fisheries included).

Year	Quarter	Denmark									Norway		Total
	Area	IIIaN	IIIaS	Div. IIIa	IVaE	IVaW	IVb	IVc	Div. IV	Div. IV + IIIaN	IVaE	Div. IV	Div. IV + IIIaN
1998	1	1.117	317	1.434	7.111	2.292	-	-	9.403	10.520	8913	8913	19.433
	2	3.881	103	3.984	131	5	124	-	259	4.140	7885	7885	12.025
	3	6.011	406	6.417	7.161	1.763	2.372	-	11.297	17.308	3559	3559	20.867
	4	2.161	677	2.838	1.051	17.752	77	-	18.880	21.041	1778	1778	22.819
	Total	13.171	1.503	14.673	15.454	21.811	2.573	-	39.838	53.009	22.135	22135	75.144
1999	1	4	12	15	2.769	1.246	1	-	4.016	4.020	3021	3021	7.041
	2	1.568	36	1.605	953	361	418	-	1.731	3.300	10321	10321	13.621
	3	3.094	109	3.203	7.500	3.710	2.584	-	13.794	16.887	24449	24449	41.336
	4	2.156	517	2.673	3.577	16.921	928	1	21.426	23.583	6385	6385	29.968
	Total	6.822	674	7.496	14.799	22.237	3.931	1	40.968	47.790	44.176	44176	91.966
2000	1	0	11	12	3.726	1.038	-	-	4.764	4.765	5440	5440	10.205
	2	929	15	944	684	22	227	-	933	1.862	9779	9779	11.641
	3	7.380	139	7.519	1.708	5.613	515	-	7.836	15.216	28428	28428	43.644
	4	947	209	1.157	1.656	111.732	76	-	113.464	114.411	4334	4334	118.745
	Total	9.257	375	9.631	7.774	118.406	818	-	126.998	136.255	47.981	47981	184.236
2001	1			302	7.341	9.734	103	72	17.250	17.250	3838	3838	21.088
	2			2.174	31	30	269	-	330	330	9268	9268	9.598
	3			2.006	15	154	191	-	360	360	2263	2263	2.623
	4			3.059	2.553	19.826	329	-	22.708	22.708	1426	1426	24.134
	Total			7.541	9.940	29.744	892	72	40.648	40.648	16.795	16795	57.443
2002	1	-	1	1	4.869	1.660	114	-	6.643	6.643	1896	1896	8.539
	2	883	161	1.045	56	9	22	-	87	970	5563	5563	6.533
	3	1.567	213	1.778	2.234	14.739	104	-	17.077	18.644	14147	14147	32.791
	4	393	100	492	1.787	24.273	335	-	26.395	26.788	2033	2033	28.821
	Total	2.843	475	3.316	8.946	40.681	575	-	50.202	53.045	23.639	23639	76.684
2003	1	-	1	1	615	581	22	-	1.218	1.218	1977	1977	3.195
	2	246	160	406	76	-	22	-	98	344	2773	2773	3.117
	3	2.984	1.005	3.989	172	1.613	89	-	1.874	4.858	5989	5989	10.847
	4	188	547	735	0	6270	457	-	6.727	6.915	644	644	7.559
	Total	3.418	1.713	5.131	863	8.464	590	-	9.917	13.335	11.383	11.383	24.718
2004	1	316	-	316	87	650	-	-	737	1.053	989	989	2.042
	2	-	-	-	-	-	7	-	7	7	660	660	667
	3	14	-	14	289	1.195	9	-	1.493	1.507	2484	2484	3.991
	4	13	-	13	93	5.683	107	-	5.883	5.896	865	865	6.761
	Total	343	-	343	469	7.528	123	-	8.120	8.463	4.998	4.998	13.461
2005	1	-	-	-	9	-	-	-	9	9	12	12	21
	2	-	-	-	151	-	-	-	151	151	352	352	503
	3	-	-	-	781	-	-	-	781	781	387	387	1.168
	4	-	-	-	-	-	-	-	-	-	211	211	211
	Total	-	-	-	941	-	-	-	941	941	962	962	1.903
2006	1	-	-	-	75	83	-	-	158	158	2.205	2205	2.363
	2	-	-	-	-	-	15	-	15	15	2.846	2846	2.861
	3	114	-	114	-	649	20	-	669	783	5.749	5749	6.532
	4	3	-	3	-	34.262	-	-	34.262	34.265	605	605	34.870
	Total	117	-	117	75	34.994	35	-	35.104	35.221		11.405	46.626
2007	1	-	-	-	561	789	-	-	1.350	1.350	74	74	1.424
	2	-	-	-	4	-	-	-	4	4	1.097	1097	1.101
	3	1	2	3	-	-	-	-	-	1	2.429	2429	2.430
	4	-	-	-	-	682	-	-	682	682	155	155	837
	Total	1	2	3	565	1.471	-	-	2.036	2.037		3.755	5.792
2008	1	125	-	125	19	86	123	-	228	353	7	7	360
	2	-	-	-	-	-	30	-	30	30	1.803	1803	1.833
	3	-	-	-	-	6.102	-	-	6.102	6.102	3.582	3582	9.684
	4	-	-	-	-	22.686	1.239	-	23.925	23.925	336	336	24.261
	Total	125	-	125	19	28.874	1.392	-	30.285	30.410		5.728	36.138
2009	1	1	-	1	22	515	-	-	537	538	2	2	540
	2	-	-	-	-	-	-	-	-	-	4.026	4026	4.026
	3	2	-	2	-	11.567	-	-	11.567	11.569	31.251	31251	42.820
	4	-	-	-	-	5.399	4	-	5.403	5.403	1.736	1736	7.139
	Total	3	-	3	22	17.481	4	-	17.507	17.510	37.015	37.015	54.525
2010	1	-	-	-	-	194	-	-	194	194	104	104	298
	2	157	-	157	-	478	59	-	537	694	17.906	17906	18.600
	3	37	-	37	-	33.618	213	-	33.831	33.868	41.883	41883	75.751
	4	8	-	8	-	30.276	38	-	30.314	30.322	984	984	31.306
	Total	202	-	202	-	64.566	310	-	64.876	65.078	60.877	60.877	125.955
2011	1	-	-	-	-	-	-	-	-	-	-	0	-
	2	-	-	-	-	-	-	-	-	-	188	188	188
	3	-	-	-	-	456	5	-	461	461	3.004	3.004	3.465
	4	-	-	-	-	2.853	-	-	2.853	2.853	18	18	2.871
	Total	-	-	-	-	3.309	5	-	3.314	3.314	3.210	3.210	6.524
2012	1	-	-	-	-	15	-	-	15	15	12	12	27
	2	-	-	-	-	-	-	-	-	-	280	280	280
	3	2	-	2	-	62	8	-	70	72	395	395	467
	4	125	-	125	-	22.204	-	-	22.204	22.329	3.900	3.900	26.229
	Total	127	-	127	-	22.281	8	-	22.289	22.416	4.587	4.587	27.003
2013	1	-	-	-	-	59	-	-	59	59	18	18	77
	2	6	-	6	-	409	-	-	409	415	10.045	10.045	10.460
	3	4.791	-	4.791	5	3.260	43	-	3.308	8.099	16.350	16.350	24.449
	4	1.366	-	1.366	-	25.211	-	-	25.211	26.577	20.537	20.537	47.114
	Total	6.163	-	6.163	5	28.939	43	-	28.987	35.150	46.950	46.950	82.100
2014	1	-	-	-	-	1.318	-	-	1.318	1.318	6	6	1.324
	2	62	-	62	-	-	2	-	2	64	3.146	3.146	3.210
	3	492	-	492	-	5.606	20	-	5.626	6.118	7.252	7.252	13.370
	4	-	-	-	-	18.006	-	-	18.006	18.006	8.260	8.260	26.266
	Total	554	-	554	-	24.930	22	-	24.952	25.506	18.664	18.664	44.170
2015	1	-	-	-	21	305	-	-	326	326	268	268	594
	2	2	-	2	-	549	-	-	549	551	6.812	6.812	7.363

Table 4 NORWAY POUT in IV and IIIaN (Skagerrak). Catch in numbers at age by quarter (millions). SOP is given in tonnes. Data for 1990 were estimated within the SXSA program used in the 1996 assessment.

Age	Year	1983				1984				1985			
	Quarter	1	2	3	4	1	2	3	4	1	2	3	4
0		0	0	446	2671	0	0	1	2231	0	0	6	678
1		4.207	1826	5825	4296	2.759	2252	5290	3492	2.264	857	1400	2991
2		1.297	1234	1574	379	1.375	1165	1683	734	1.364	145	793	174
3		15	10	17	7	143	269	8	0	192	13	19	0
4+		0	2	0	0	0	0	0	0	1	0	0	0
SOP		58587	69964	216106	131207	56790	56532	152291	110942	57464	15509	62489	92017
Age	Year	1986				1987				1988			
	Quarter	1	2	3	4	1	2	3	4	1	2	3	4
0		0	0	0	5572	0	0	8	227	0	0	741	3146
1		396	260	1186	1791	2687	1075	1627	2151	249	95	183	632
2		1069	87	245	39	401	60	171	233	700	74	250	405
3		72	3	6	0	12	0	0	5	20	0	0	0
4+		3	0	0	0	1	0	0	0	0	0	0	0
SOP		37889	7657	45085	89993	33894	15435	38729	60847	22181	3559	21793	61762
Age	Year	1989				1990				1991			
	Quarter	1	2	3	4	1	2	3	4	1	2	3	4
0		0	0	159	4854	0	0	20	993	0	0	734	3486
1		1736	678	1672	1741	1840	1780	971	1181	1501	636	1519	1048
2		48	133	266	93	584	572	185	116	1336	404	215	187
3		6	6	5	13	20	19	6	4	93	19	22	18
4+		0	0	0	0	10	0	0	0	6	0	0	0
SOP		15379	13234	55066	82880	28287	39713	26156	45242	42776	20786	62518	64380
Age	Year	1992				1993				1994			
	Quarter	1	2	3	4	1	2	3	4	1	2	3	4
0		0	0	879	954	0	0	96	1175	0	0	647	4238
1		3556	1522	3457	2784	1942	813	1147	1050	1975	372	1029	1148
2		1086	293	389	267	699	473	912	445	591	285	421	134
3		118	20	1	2	15	58	19	2	56	29	71	0
4+		3	0	0	0	0	0	0	0	0	0	0	0
SOP		64224	27973	114122	96177	36206	29291	62290	53470	34575	15373	53799	79838
Age	Year	1995				1996				1997			
	Quarter	1	2	3	4	1	2	3	4	1	2	3	4
0		0	0	700	1692	0	0	724	2517	0	0	109	343
1		3992	1905	2545	3348	535	560	1043	650	672	99	3090	1922
2		240	256	47	59	772	201	1002	333	325	131	372	207
3		6	32	3	3	14	38	37	0	79	119	105	35
4+		0	0	0	0	0	0	0	0	0	0	0	0
SOP		36942	28019	69763	97048	21888	13366	74631	46194	15320	8708	78809	54100
Age	Year	1998				1999				2000			
	Quarter	1	2	3	4	1	2	3	4	1	2	3	4
0		0	0	94	339	0	0	41	1127	0	0	73	302
1		261	210	411	531	202	318	1298	576	653	280	1368	4616
2		690	310	332	215	128	220	338	160	185	207	266	245
3		47	18	2	13	73	93	35	23	3	48	20	6
4+		8	24	0	0	1	0	0	0	0	0	0	0
SOP		19562	12026	20866	22830	7833	12535	41445	30497	10207	11589	44173	119001
Age	Year	2001				2002				2003			
	Quarter	1	2	3	4	1	2	3	4	1	2	3	4
0		0	0	32	368	0	0	340	290	0	0	7	1
1		220	133	122	267	485	351	621	473	59	64	191	54
2		845	246	27	439	148	24	284	347	76	49	121	161
3		35	100	1	1	17	5	24	26	22	25	16	32
4+		0	0	0	0	0	0	0	0	0	0	0	1
SOP		21400	11778	4630	26565	8553	6686	32922	28947	3190	3106	10842	7549
Age	Year	2004				2005				2006			
	Quarter	1	2	3	4	1	2	3	4	1	2	3	4
0		0	0	14	57	*	*	*	*			10	368
1		13	4	51	100	*	*	*	*	30	56	130	1086
2		55	16	51	78	*	*	*	*	52	45	65	50
3		9	6	7	2	*	*	*	*	9	24	7	1
4+		0	0	0	0	*	*	*	*	0	0	0	0
SOP		2040	667	4018	6762	8	8	13	13	2205	2848	6551	34949
Age	Year	2007				2008				2009			
	Quarter	1	2	3	4	1	2	3	4	1	2	3	4
0		0	0	0	0	0	0	0	1179	0	0	58	12
1		20	41	32	10	5	54	166	438	50	36	621	169
2		43	26	16	6	10	41	115	31	1	47	613	27
3		0	0	2	1	0	0	0	0	0	5	9	1
4+		0	0	0	0	0	0	0	0	0	0	0	0
SOP		1428	1100	2430	838	361	1840	8532	24111	538	2105	36661	6509
Age	Year	2010				2011				2012			
	Quarter	1	2	3	4	1	2	3	4	1	2	3	4
0		0	0	0	0	0	0	0	1	0	0	1	135
1		6	799	1118	716	0	1	44	23	1	5	8	404
2		1	905	738	331	0	5	69	61	0	2	4	185
3		0	17	15	0	0	0	4	0	0	2	1	10
4+		0	0	0	0	0	0	0	0	0	0	0	0
SOP		198	40322	57487	33071	0	222	3749	2872	29	281	469	26168
Age	Year	2013				2014				2015			
	Quarter	1	2	3	4	1	2	3	4	1	2		
0		0	0	8	76	0	0	141	884	0	0		
1		5	631	805	1287	10	33	197	522	48	442		
2		0	39	131	199	51	60	167	115	7	16		
3		0	4	18	27	1	2	3	0	1	5		
4+		0	0	0	0	0	0	0	0	0	0		
SOP		79	10460	24444	47126	1324	3212	13384	26244	594	7363		

In 2007-08: Catch numbers from Norwegian fishery calculated from Norwegian total catch weight divided by mean weight at age from Danish Fishery.

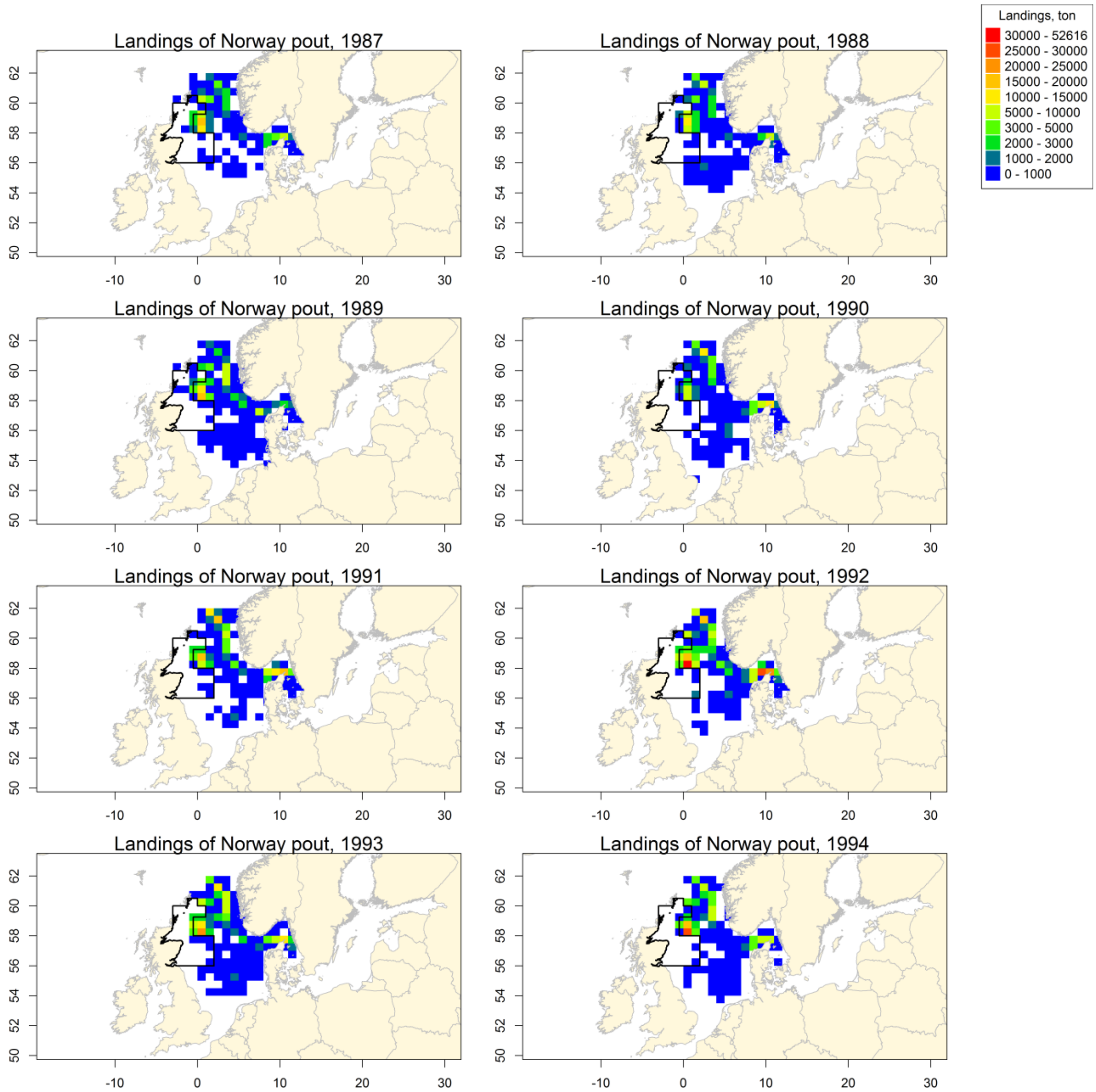


Figure 1. Landings from the small meshed Danish industrial fishery for of Norway pout by year and ICES rectangles for the period 1987-2015. The “Norway pout box” is shown on the maps.

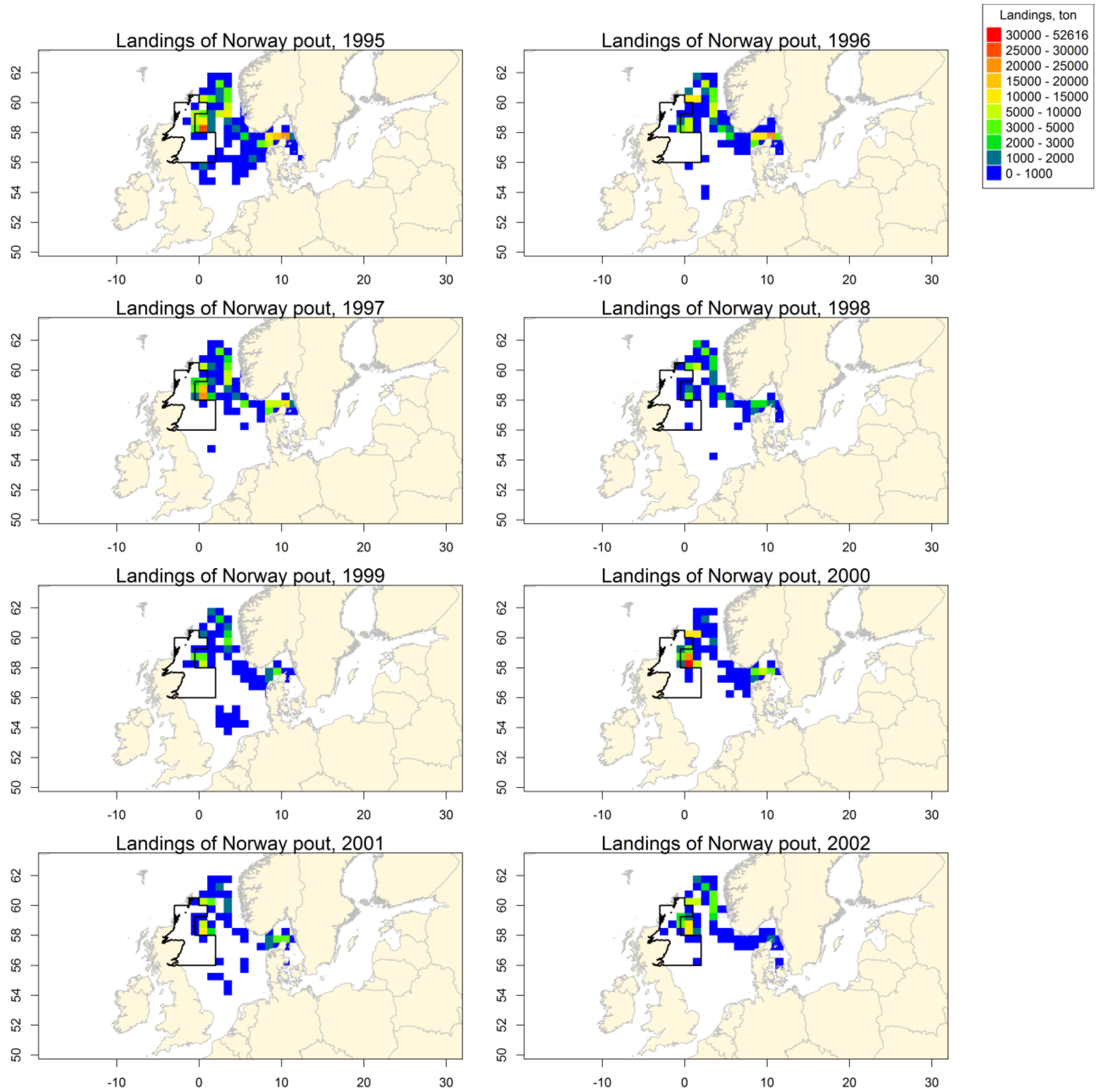


Figure 1. (Continued).

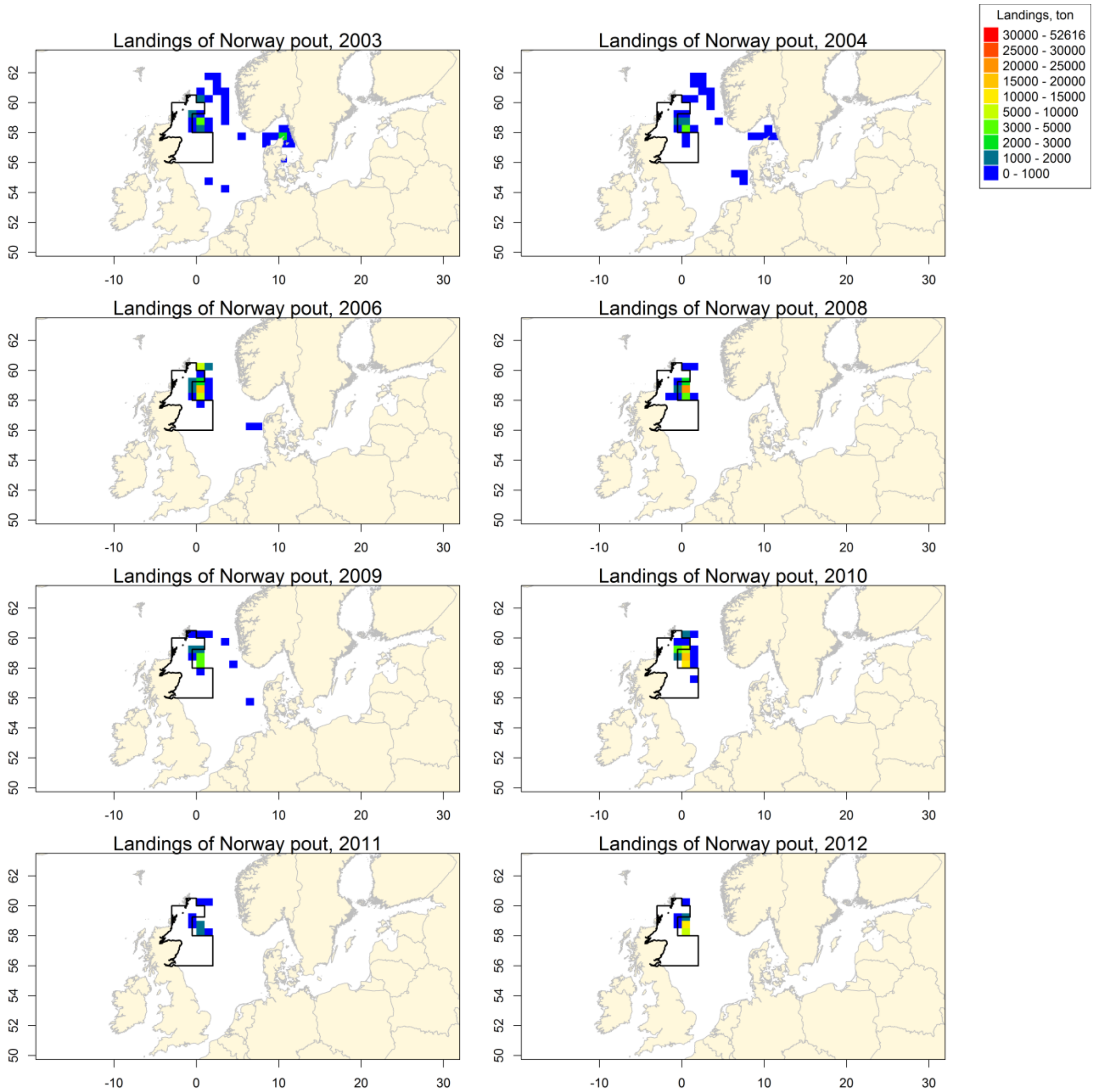


Figure 1. (Continued)

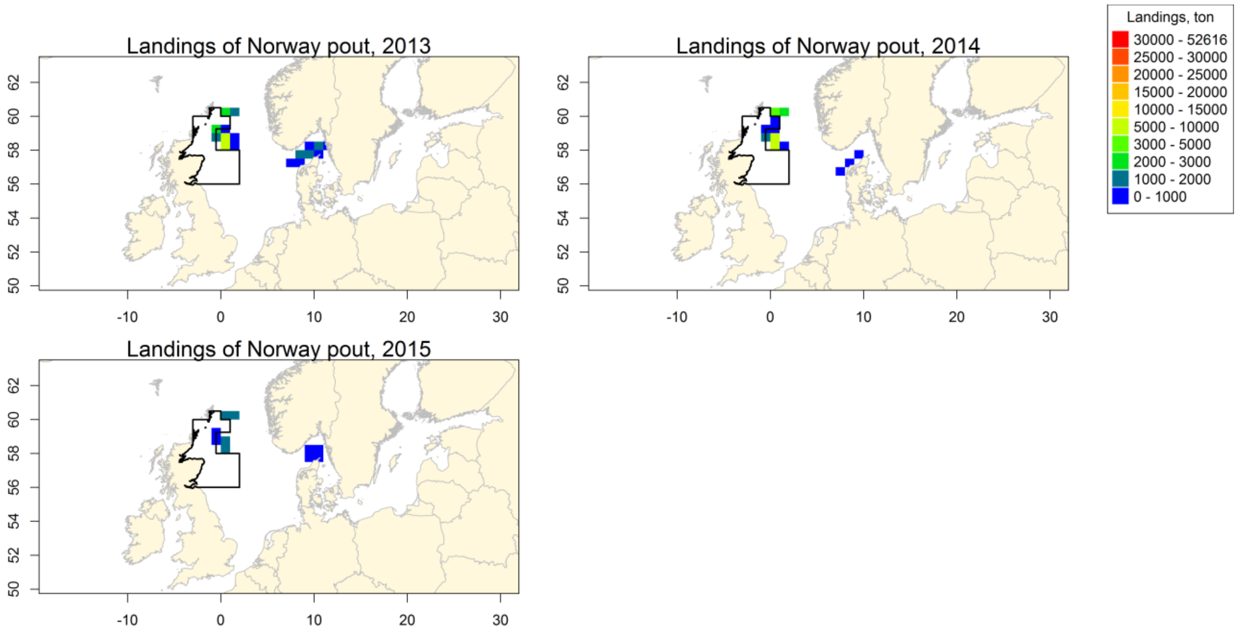


Figure 1. (Continued).

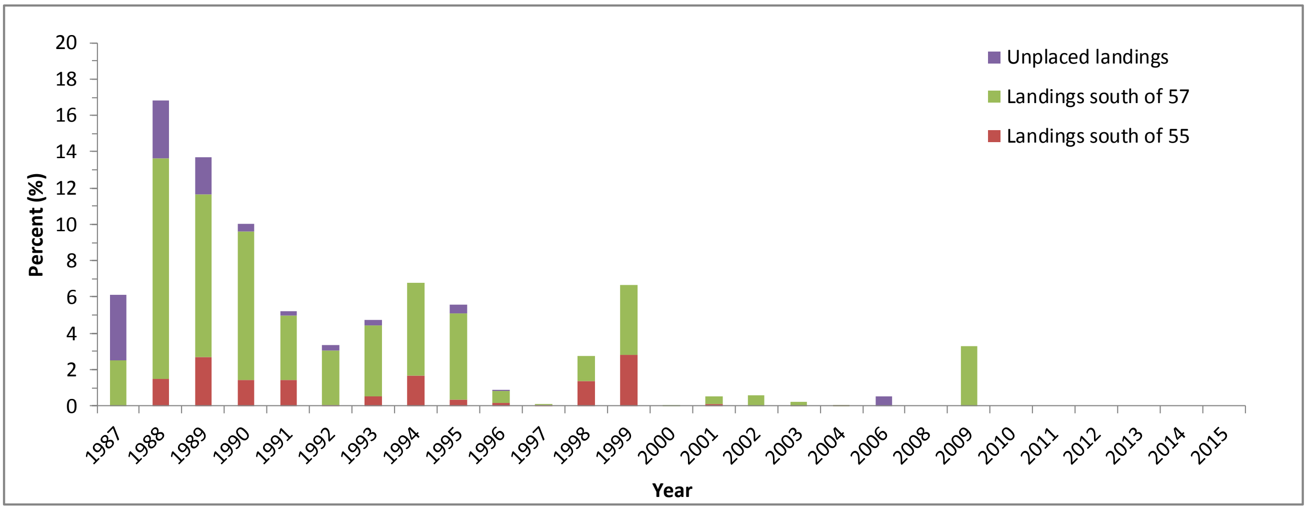


Figure 2. Relative proportions of total landings (catches) south of 55 degrees N and 57 degrees N in the Danish Norway pout fishery, as well as the proportion of unallocated landings.

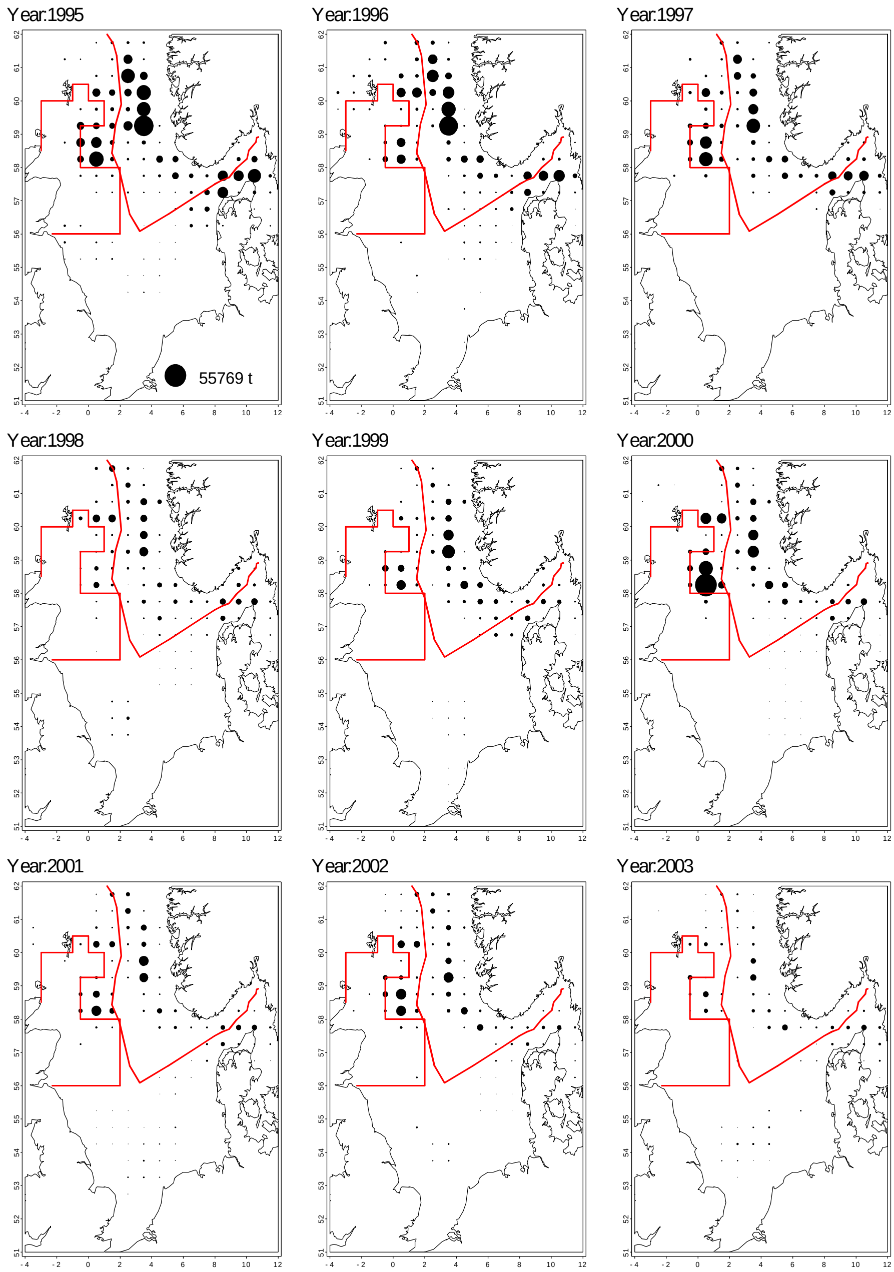


Figure 3. Landings of Norway pout by year and ICES rectangles for the period 1995-2003. Landings include Danish and Norwegian landing for the whole period. The area of the circles represents landings by rectangle. All rectangle landings are scaled to the largest rectangle landings shown at the 1995 map. The "Norway pout box" and the boundary between the EU and the Norwegian EEZ are shown on the map. (From Anon. 2005 and ICES 2007).

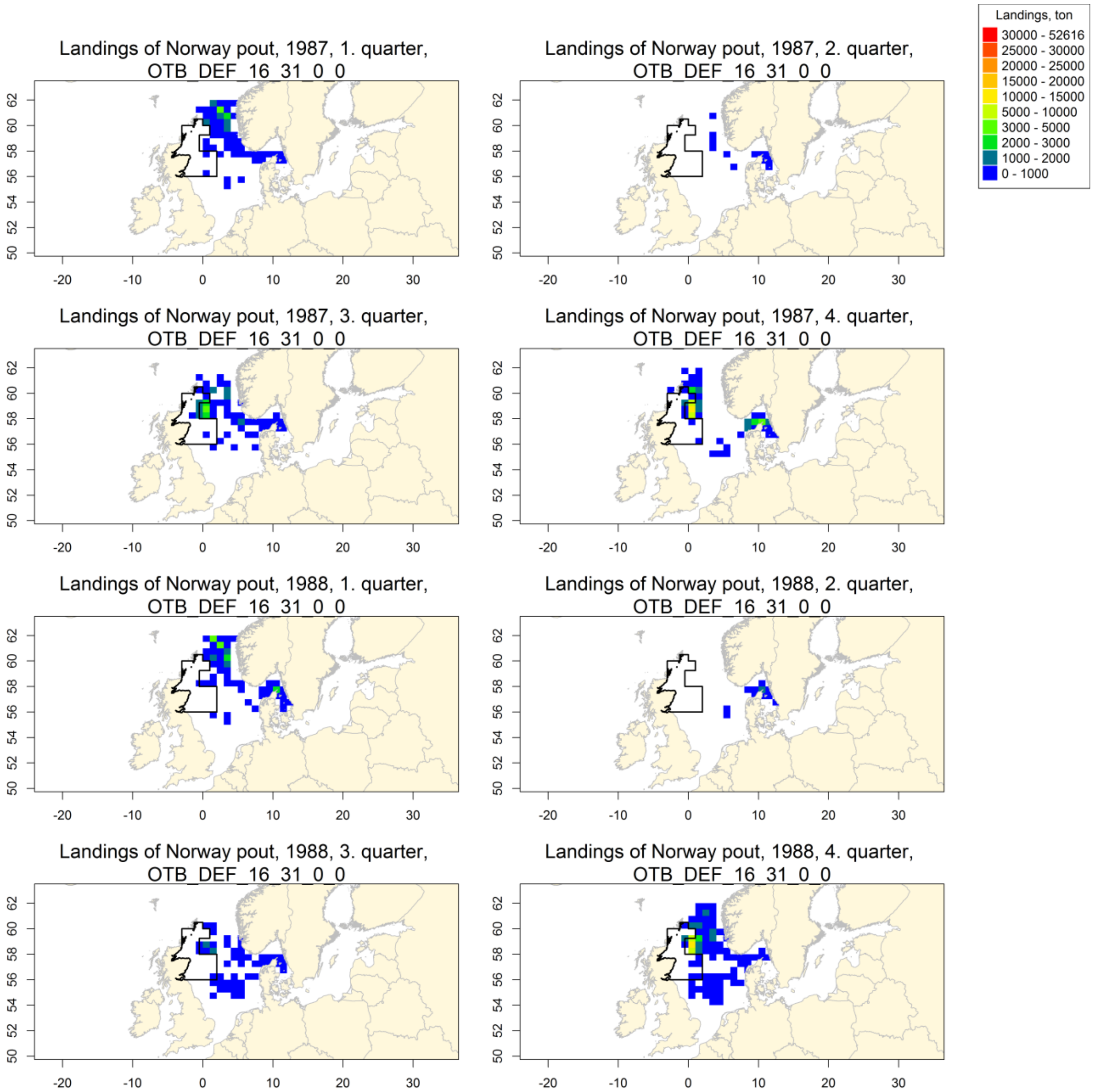
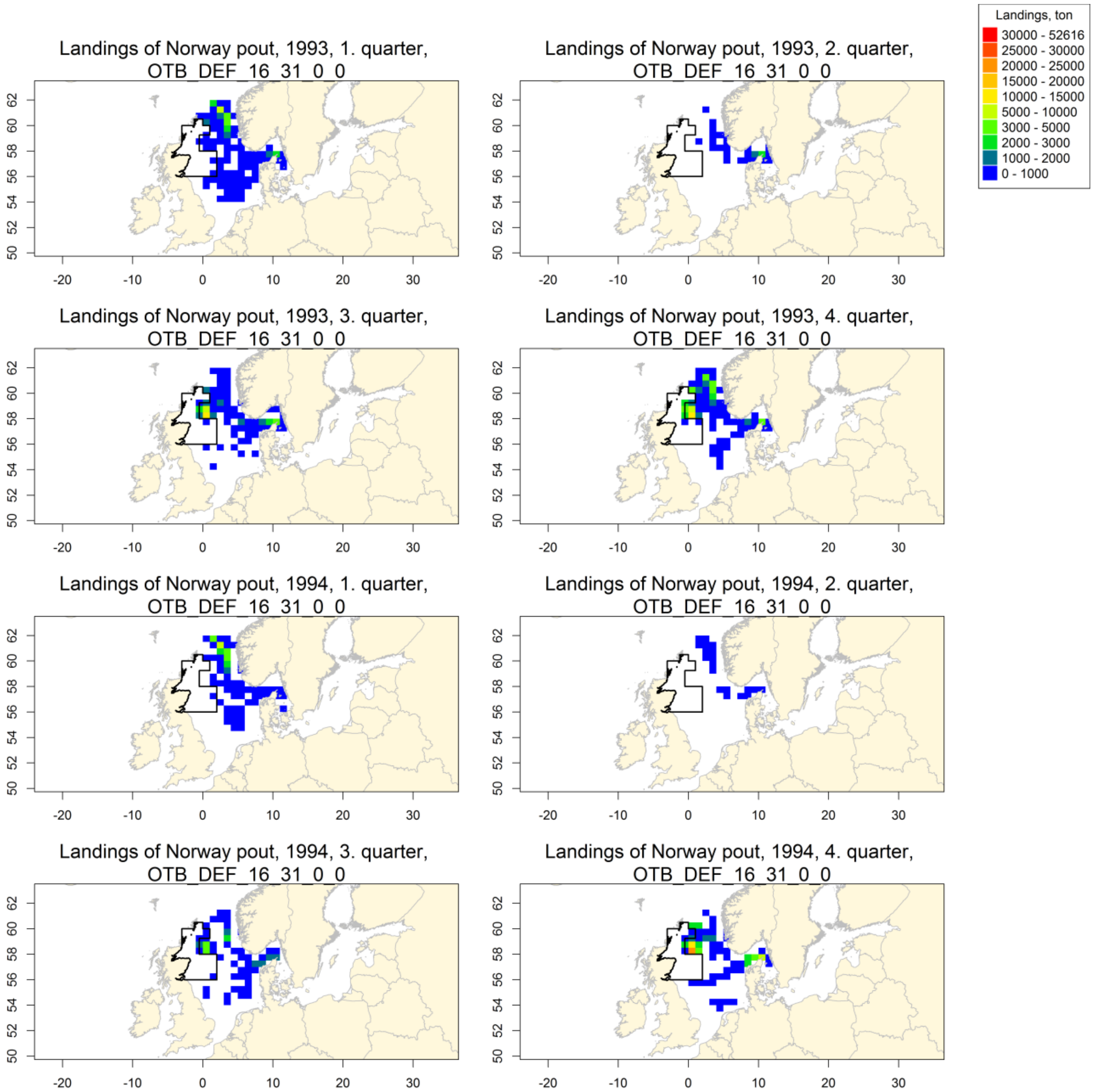


Figure 4. Distribution of landings from the small meshed Danish industrial fishery for Norway pout by year, quarter, ICES rectangles, and metier for selected years in the period 1987-2015. The “Norway pout box” is shown on the maps.



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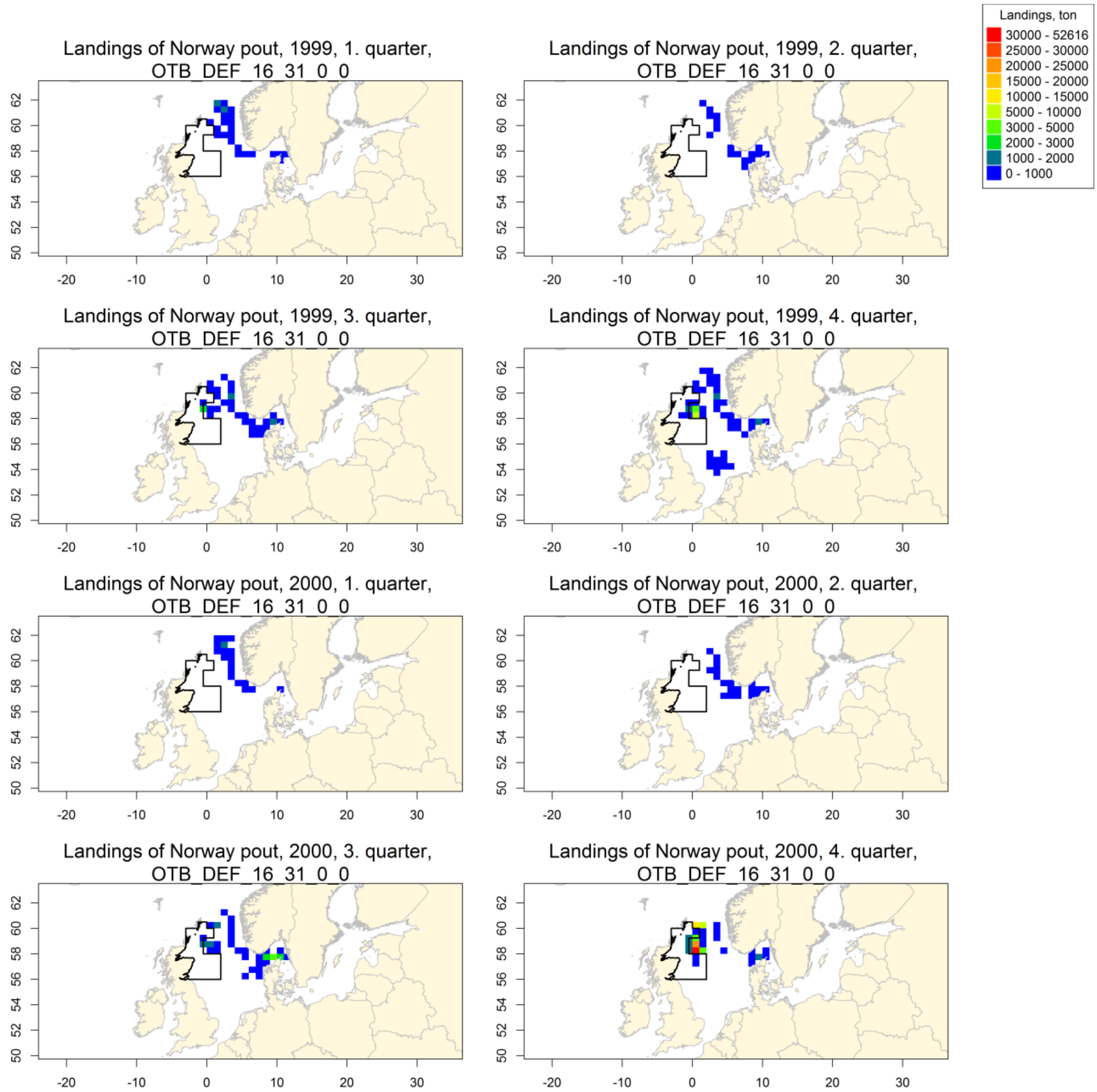

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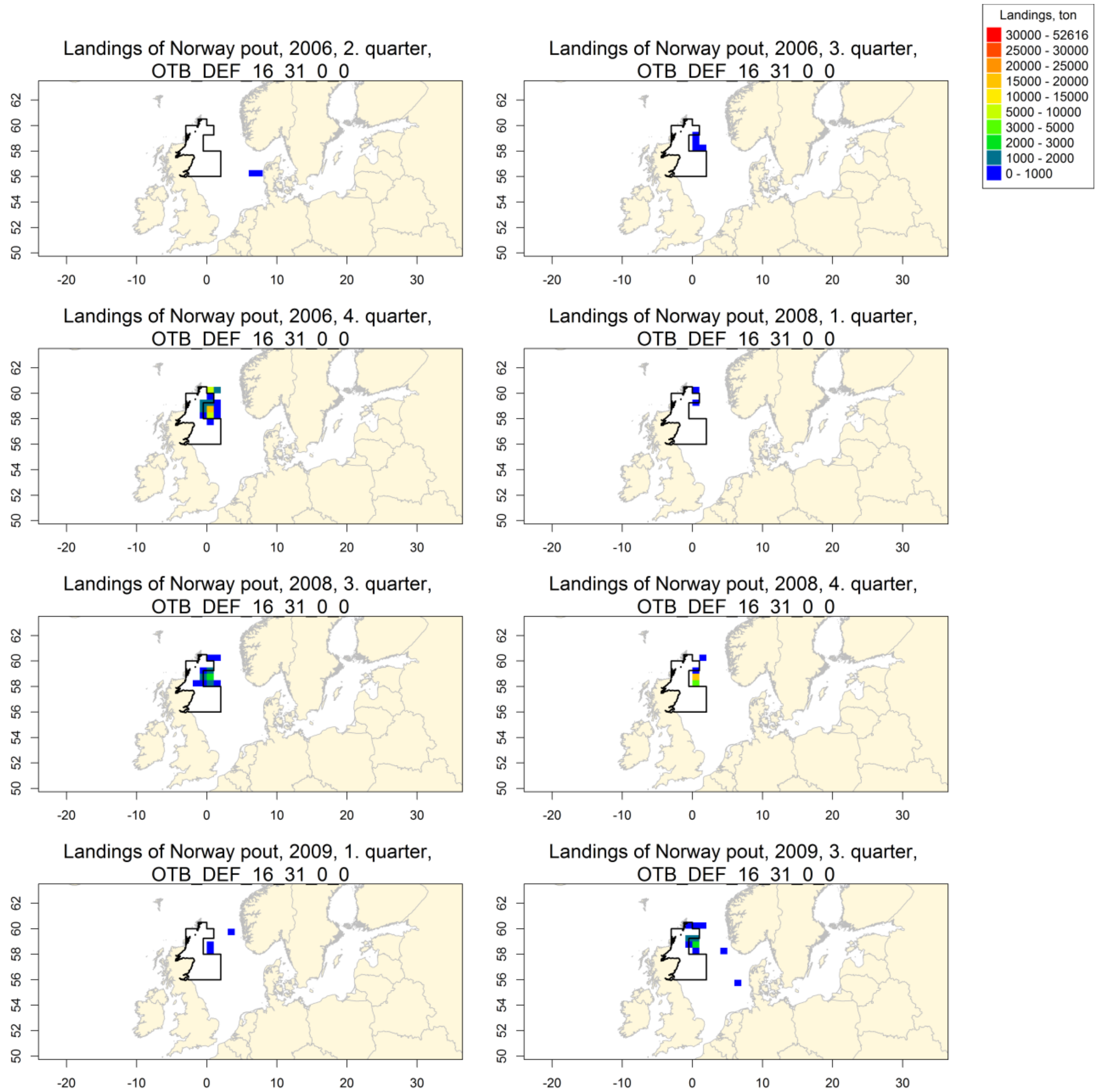

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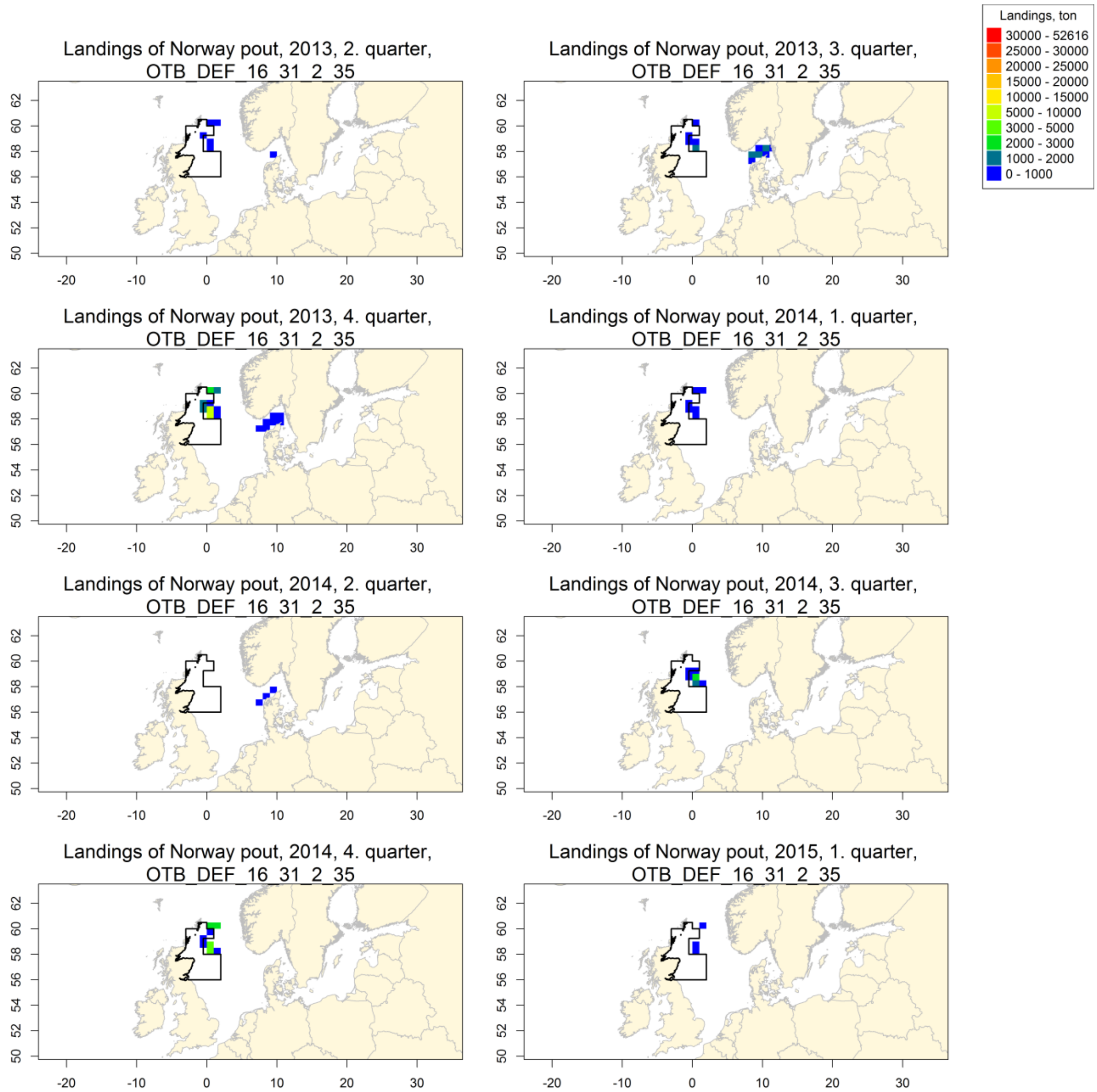

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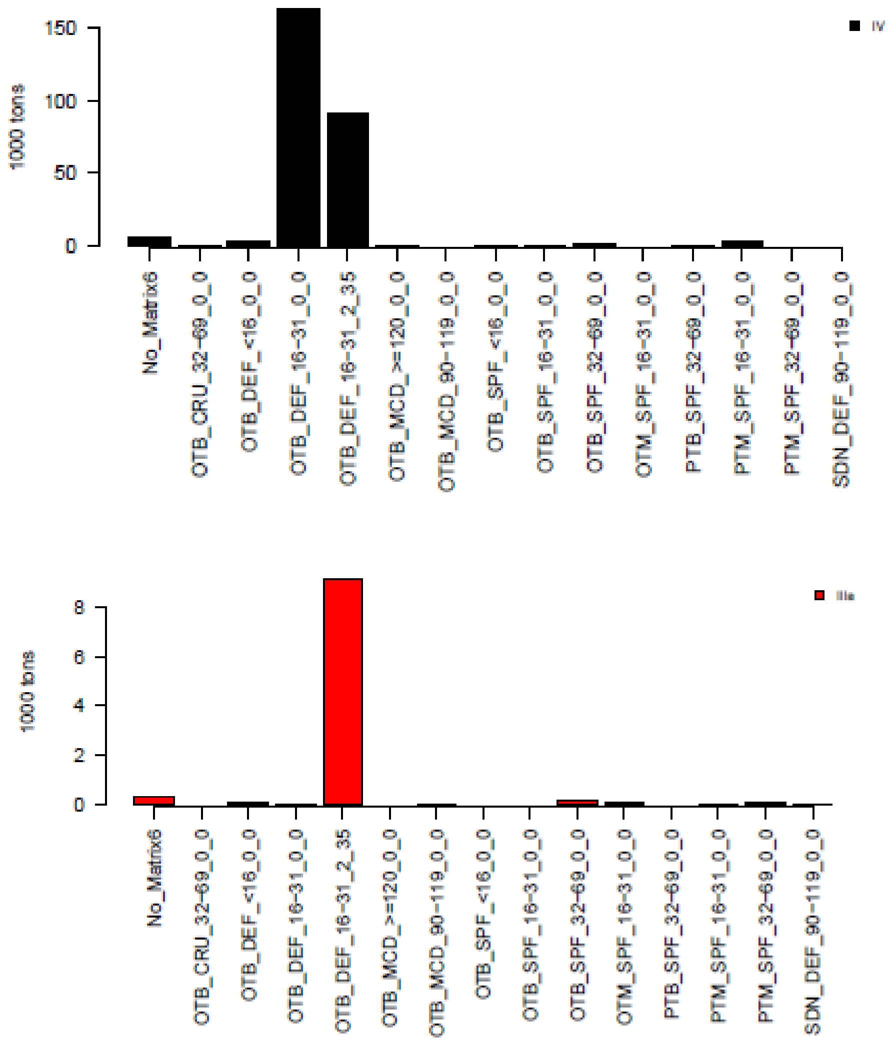


Figure 4. (Continued). Average landings by metier in the period 2004-2015 by area (IV = North Sea; IIIa = Skagerrak-Kattegat) for the Danish small meshed fishery targeting Norway pout.

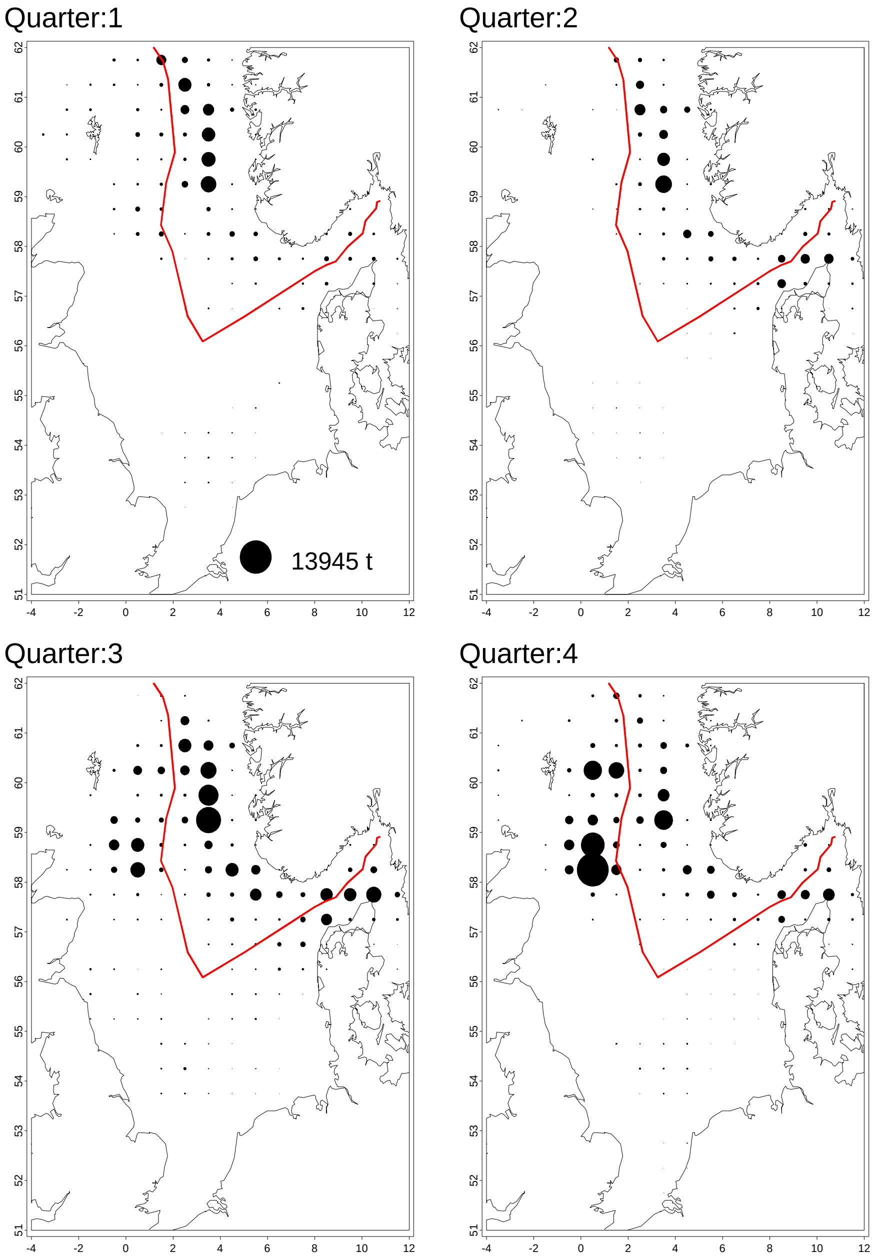


Figure 5. Average Danish and Norwegian landings of Norway pout by quarter of the year and ICES rectangles for the period 1994-2003. The area of the circles represents landings by rectangle. All rectangle landings are scaled to the largest rectangle landings shown at the quarter 1 map. (From Anon. 2005 and ICES 2007).

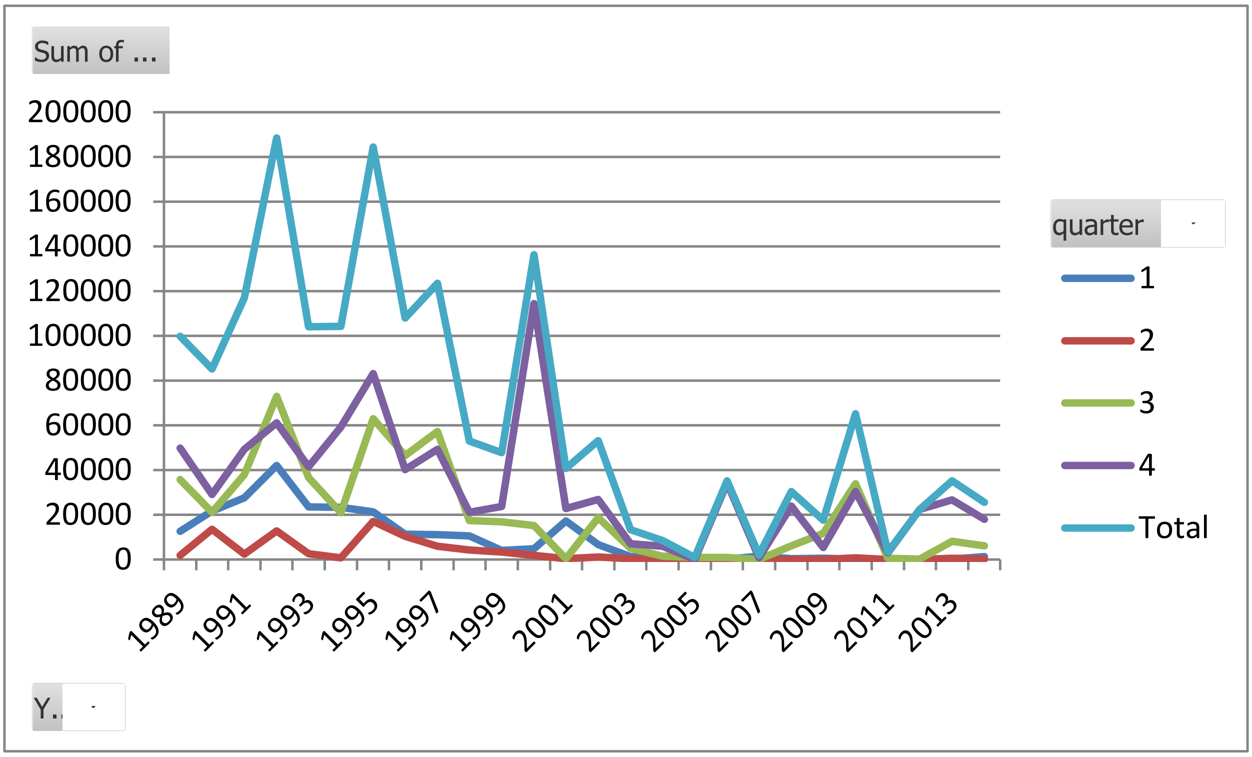


Figure 6. Quarterly distribution of Danish landings by year. (Based on data from the ICES WGNSSK September 2015 Norway pout assessment).

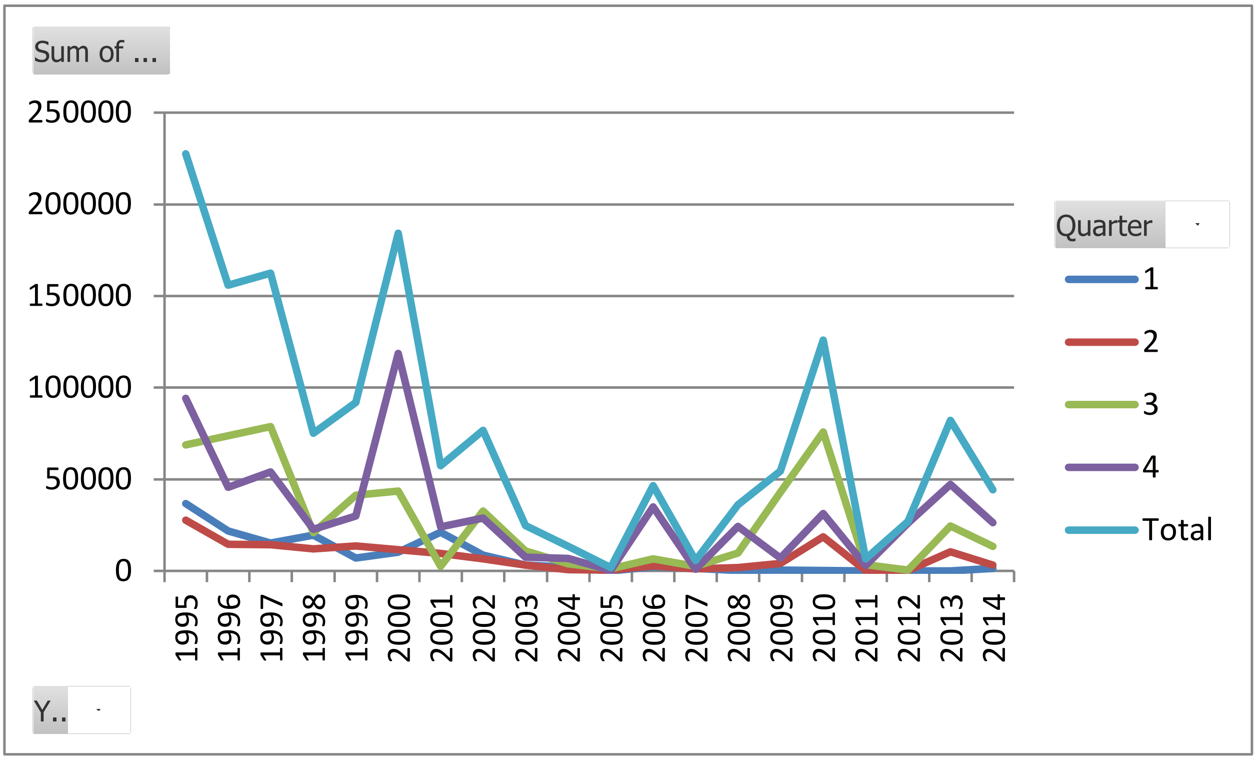


Figure 7. Quarterly distribution of combined Danish and Norwegian landings by year. (Based on data from the ICES WGNSSK September 2015 Norway pout assessment).

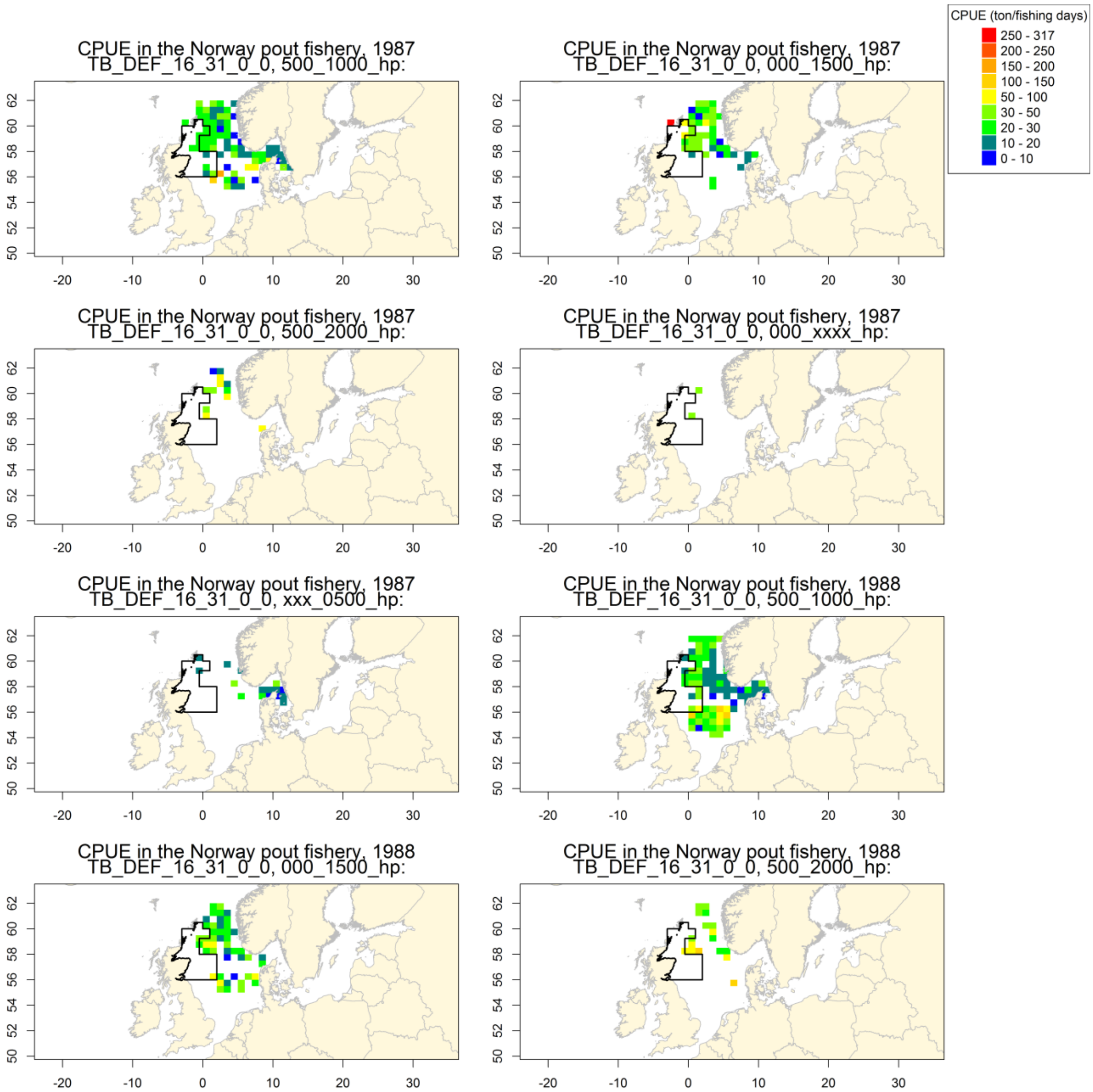
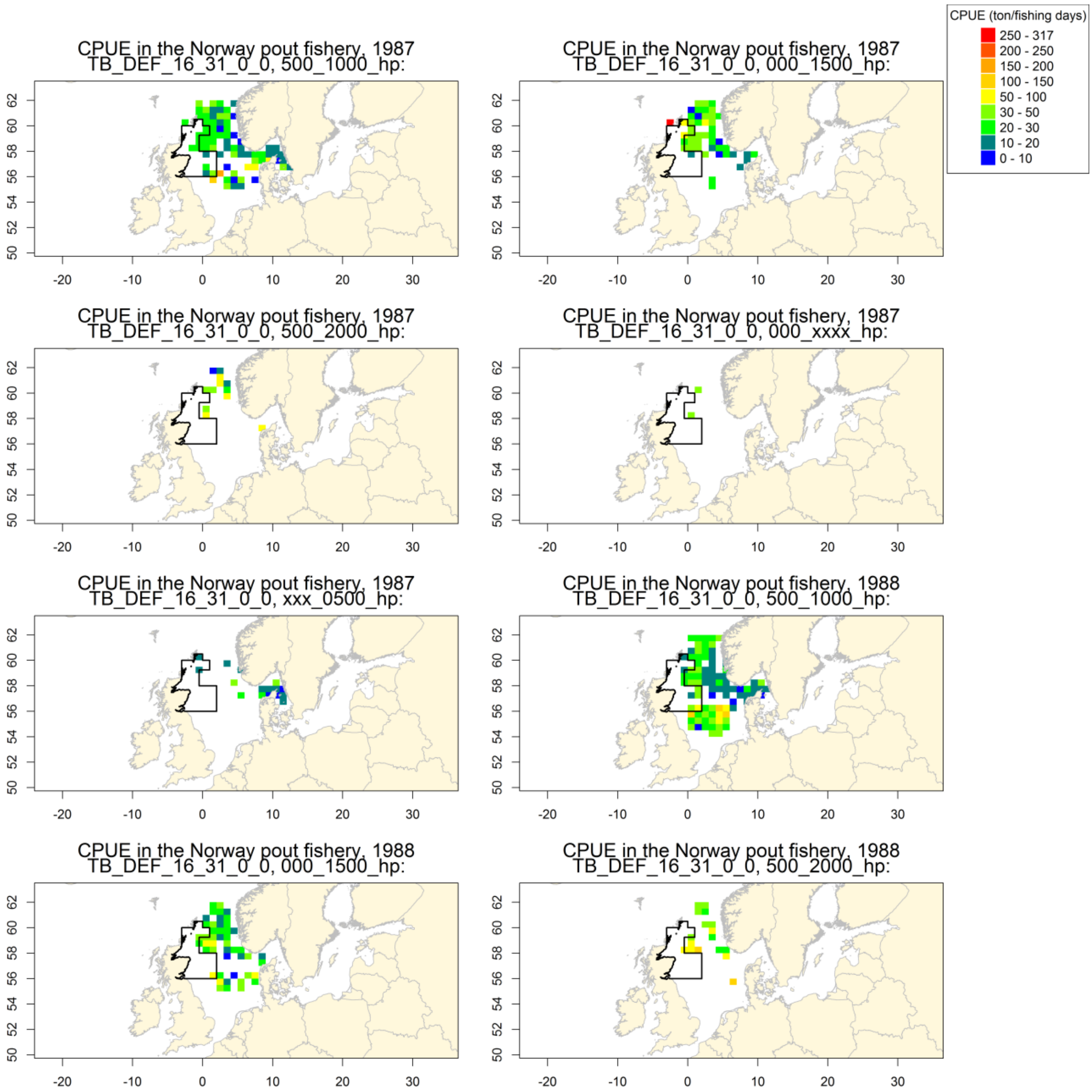


Figure 8. Fishing power and catch efficiency comparison between vessel groups. Catch rates (ton/fishing day) for the small meshed Danish industrial fishery for of Norway pout by year, ICES rectangles, metier, and engine horse power class for selected years in the period 1987-2015. The “Norway pout box” is shown on the maps.



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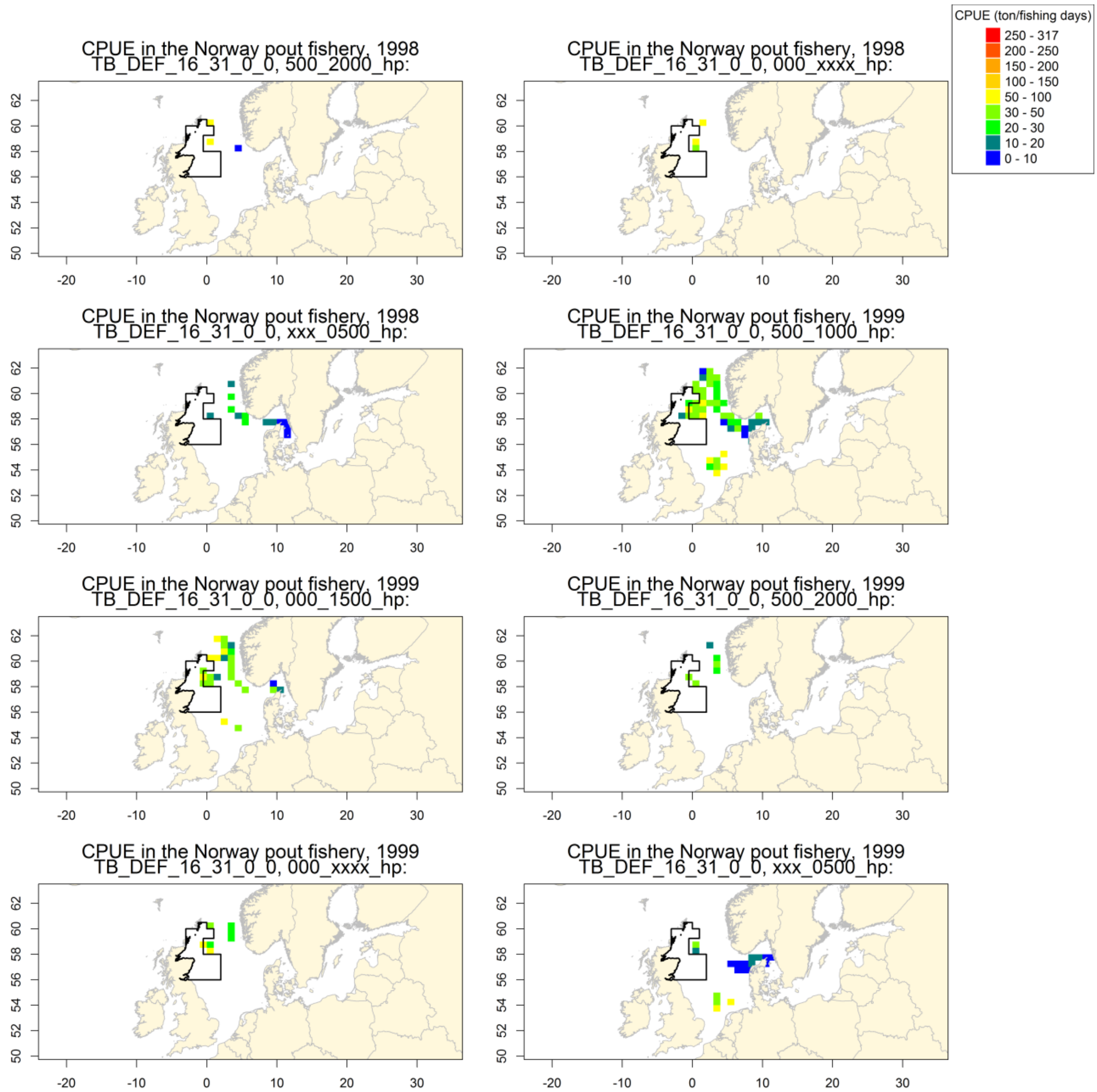

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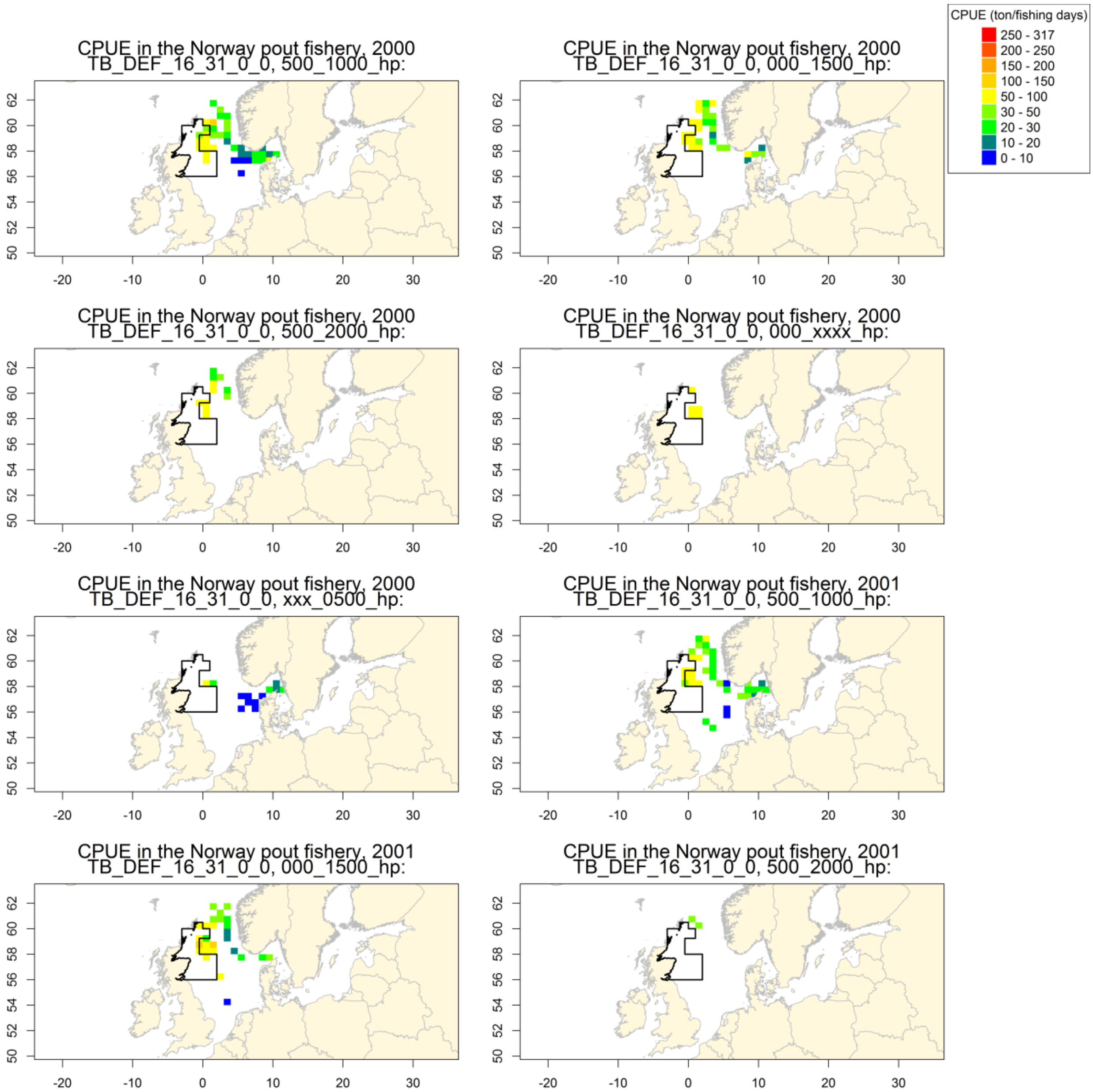

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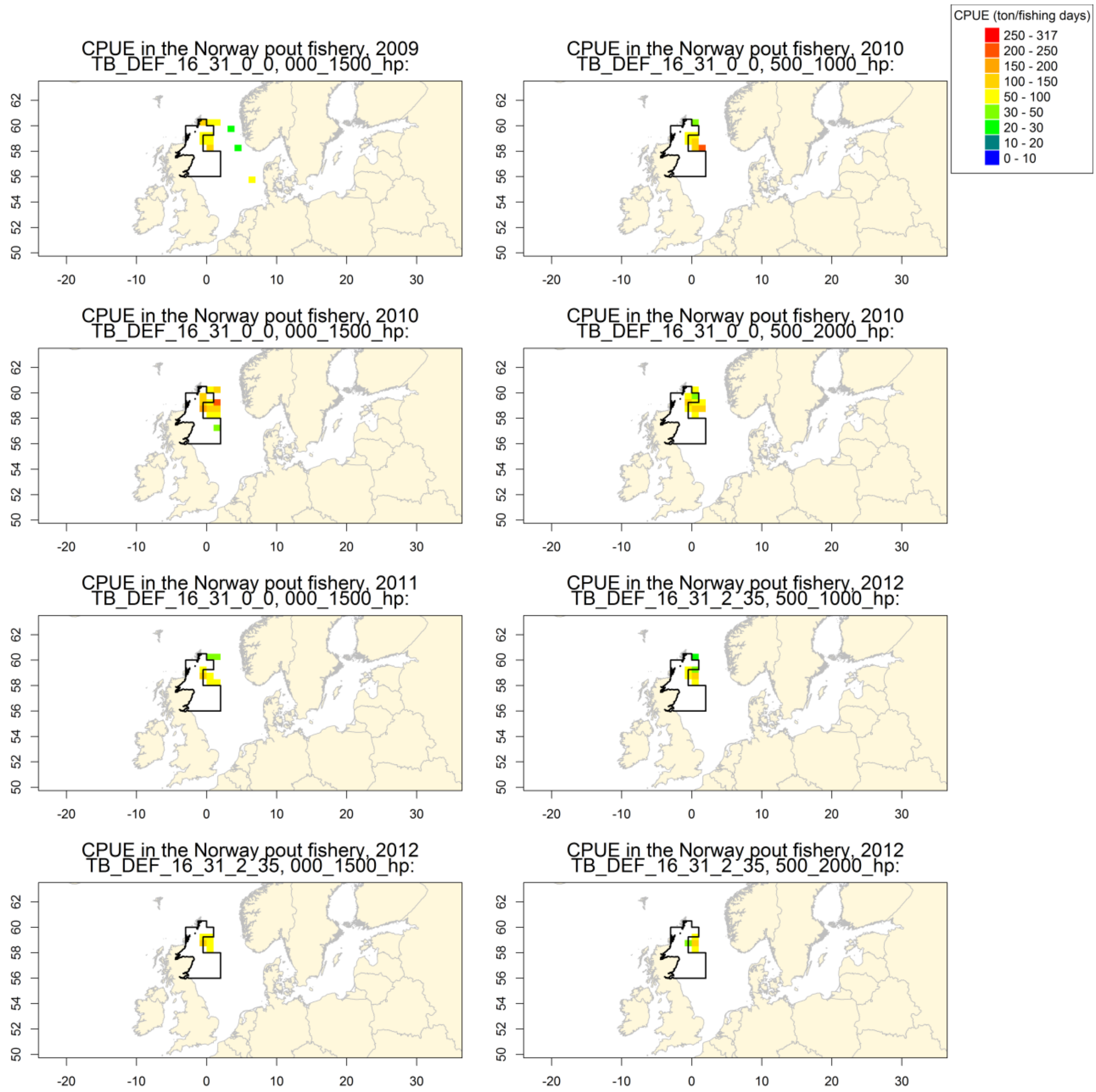

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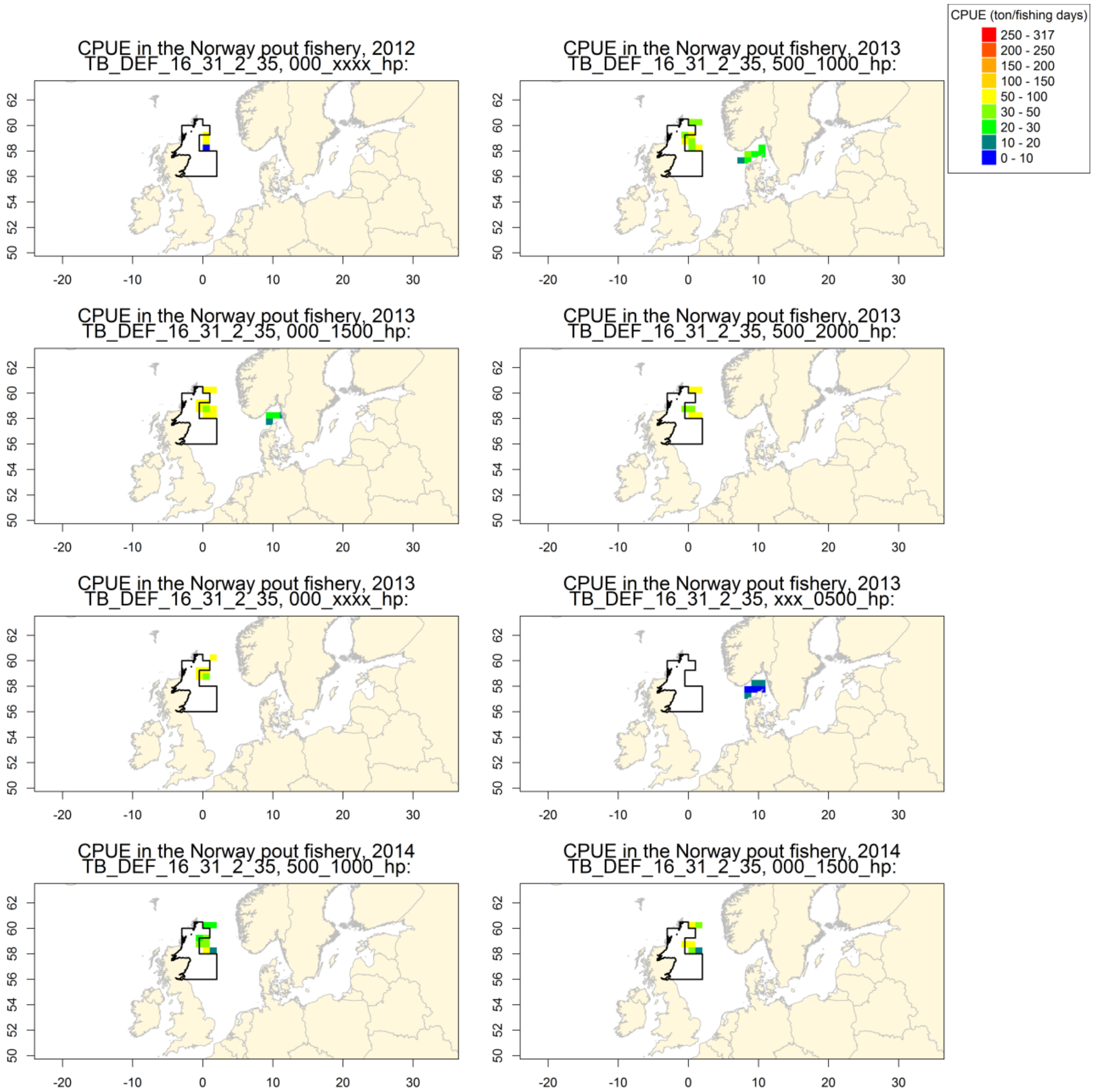


Figure 8. (Continued).

A.3. Sampling of the Danish Targeted Norway pout Fishery

Sampling scheme, procedures and background

The EU Data Collection Regulation (DCR), i.e. the EU Regulation (EU1639/2001), was implemented in 2002. On national basis the existing data collection programmes were accordingly further developed to be more uniform programmes across EU which affected the market sampling procedures for the EU fisheries. According to the DCR, minimum levels of data collection by species were set where a minimum number of market samples per tonnes of landing were required. The national market sampling programmes have been adjusted accordingly. In general, there was set a level of minimum 1 sample per 1000 tonnes landed for Norway pout in the North Sea and Skagerrak-Kattegat. Furthermore, each country was obliged to sample foreign vessels landing in their country.

The DRC was revised in 2008 where a new Data Collection Framework (DCF) under the Council Regulation (EC) No 199/2008 (EU 2008a) came into force from 2009 and has been the legal basis until 2017. The implementation decision to the DCF is given in the Commission Decision EC No. 2008/949/EC (EU 2008b). The EC No. 2008/949/EC regulation gives all the details on how the national data collection programs should be set up. The sampling of the Danish fishery data is conducted according to the standards set in this regulation and described in the Danish National Programme for Collection of Fisheries Data (2011-2013) and the Annual Report on the Danish National Data Collection Program (2015 last version). This sampling programme of the Danish fishery has been in force and conducted in the period from 2008/2009 to 2016, however, there will be introduced a new implementation regulation of the EC No 199/2008 regulation from 2017 onwards. The description of this current sampling according to the DCF Programmes and the annual reports are available from the EU Commission web-site https://datacollection.jrc.ec.europa.eu/ and summarised below. Discard sampling of Danish human consumption fishery including the small meshed shrimp fishery where small by-catches of Norway pout is taken is described in Storr-Poulsen et al. (2012).

The Norway pout assessment includes landings (catch) data from the period 1983 onwards. Besides the logbook information reported from the fishery there has been harbour samplings of the Danish commercial small meshed fishery during the whole period since 1983. The trawl fisheries targeting small demersal fish (OTB_DEF_16-31_0_0 up to 2011 and OTB_DEF_16_31_2_35 form 2012 onwards), i.e. the bottom trawl fishery targeting small demersal fish in the North Sea which is a Norway pout fishery, is in the sampling process a metier which in IV +VIIId is not merged with other metiers. The metier is sampled concurrently in harbours/at markets by purchasing unsorted samples (https://datacollection.jrc.ec.europa.eu/). The fishery is for Norway pout and no discard occur in the fishery as all catches are landed unsorted and used for fish meal and oil production. Therefore, catches are sampled in the harbours. This minimizes the costs for sampling. It is not physical possible for the vessels participating in this fishery to discard the catches when it has been taken on board.

Sampling scheme 1 is applied (https://datacollection.jrc.ec.europa.eu/) – see below. In relation to the harbour sampling of landings for reduction purposes the industrial fishery is divided into four types of fisheries; the sandeel fishery, the sprat fishery, the Norway pout fishery and the blue whiting fishery. According to sampling scheme 1 there is collected information of landing by all species caught and length measurements are made for all species. From the industrial landings representative samples are taken from the landings, and the fish in the samples are length measured, weighted, aged and maturity determined. The sampling is stratified by quarter and subdivision. Typically, there is taken at least one sample for every 1000 ton of landings.

Sampling of landings and data acquisition: According to the legislation information on fish and shellfish sold in Danish harbours has to be reported to the Danish AgriFish Agency. The registration and information duty applies to the following persons and parties:

- Storage warehouses, cold storage warehouses, or other establishments receiving fish and shellfish with purpose for sale, storage, sorting, or other liking treatments before the fish is sold to first hand buyers.

- Persons or parties that as a part of their trade buy fish directly from the fishermen for sale purposes on the home-market, export including transistation, for conservation purposes or processing for later sale.
- Persons or parties receiving fish directly from the fishermen in cases where the sale has taken place before the landing of the fish.
- Fishermen selling the catch directly to the consumer, lands it directly in a foreign country, export it including transit or process the fish from own landing.

Therefore, all information on sold fish and shellfish are registered and all these information are stored in the Sales Notes database which is a computerized database and includes among others the following information:

- Vessel number.
- Landing place and buyer.
- Species and size-class.
- Quality and purpose (e.g. human consumption).
- Weight in kilo and value in national currency (exchanged to DKK)

The information in the Sales Notes database is at present registered according to the provisions of Council Regulation (EC) No 1224/2009 and No 404/2011 (previously according to Regulation EC No 2847/93 and No 104/2000). Conversion factors for raising from gutted weight to live weight is estimated. It should be noted that all landings are recorded and there is no derogation for vessels less than 10 meters. This means, a 100% coverage for all landings including all other countries flagged vessels landing in Denmark.

The Danish fishery can be divided into two categories: A fishery with landings only for human consumption purposes and the so-called "Industrial fishery", where all the landings are made for reduction purposes (fish meal and oil).

Collecting data on landings designated reduction purposes: For landings made for reduction purposes only the target-species is registered. Therefore, the Sales Notes database does not contain reliable information on by-catches taken by industrial fishing fleet. In order to be able to estimate species composition of the industrial landings additional information has to be collected. The method and data used in estimation of landings by species is described in the following.

The objective of the Danish sampling scheme for industrial landings is to collect data needed for estimation of the species composition of landings by statistical rectangle and month and for the collection of biological parameters such as length, weight and age by species landed.

A number of random sub-samples are taken from the landings by the fisheries control authorities. The samples are sorted and weighted by species. The information registered includes e.g.:

- The vessel number.
- Landing harbour and landing date.
- Total landing in kilos.
- Total weight in grams per sample.
- Weight in grams per species.

In addition to the above-mentioned samples, fisheries control authorities collects a number of samples, which are delivered to DTU Aqua. These samples are sorted by species and each species is length measured, weighed and selected species are aged.

The species composition of the landings is derived by metier (the Norway pout fishery, the sprat fishery and the sandeel fishery) as follows: The total landings for reduction purposes by month and area are calculated using the sales note database. The landings are then allocated to statistical rectangle using the relative geographical distribution from the logbook database of landings identified as have been taken for reduction purposes. The output is the total industrial landings by statistical rectangle and month.

The relative species composition by statistical rectangle and month is estimated using the information in the species composition and biological databases. An average composition by rectangle is estimated as the mean of all samples from the rectangle. If more than one sample is taken from the same landing, a mean composition of the landing is calculated and treated as one sample.

After calculation of average composition by rectangle a new average composition is calculated taking into account the species composition in all neighbouring rectangles. Taking the mean species composition of the rectangle and all 8 surrounding rectangles does this.

The total landings by species, statistical rectangle and month are calculated using the estimated species composition and total landings by rectangle and month.

The estimation procedure is illustrated by the flow diagram below.

SALES NOTES DATABASE
(total catch by ICES division and month)

LOGBOOK DATABASE
(relative distribution of landings by
ICES statistical rectangle and month)

Total landing by ICES statistical rectangle and month

SPECIES COMPOSITION DATABASE
(relative species composition by statistical
rectangle and month)

Total landings by species, ICES statistical rectangle and month

The information on landings is merged with other fishery dependent data and stored in the DFAD database.

Certainty in the sampling schemes over time

The uncertainty in the Danish Norway pout landings with respect to catch composition varies over time in the assessment period as a result of different sampling principles as well as introduction of various regulations to reduce by-catch in the fishery (see also **Section 3** below).

The sampling of the Danish Norway pout fishery (as described above) has not changed in the period 2002 to 2016.

From 1988 onwards, the 9-square system was introduced as the basic principle for estimating the catch composition in the small meshed fishery for reduction purposes in the North Sea and Skagerrak-Kattegat. This system introduced a model for selecting, using and weighing samples from the 9 surrounding squares if there were no observations/samples for a given square for given quarter. This system reduced uncertainty in the estimation of the catch composition of the landings.

From 1996 onwards, there was introduced a new randomized system for selecting vessels and fishing trips for sampling and fishing control in the harbours. This is the so-called "pling-system" where a random number generator determined which vessels and trips there should be sampled and controlled. Also this system reduced uncertainty in the estimation of the catch compositions of the landings and improved the efficiency of the fishing control. Before 1996 the sampling of the fishing trips and vessels conducting Norway pout fishery was not randomized and not as covering as the randomized and more extensively covering harbour sampling from 1996 onwards.

From 1996 onwards, the by-catch quotas for herring in the small meshed fishery for reduction purposes in respectively the North Sea and IIIa (Skagerrak-Kattegat) was introduced in the yearly EU TAC-Quota Regulations based on the yearly Agreed Records between EU and Norway (see **Section 3** below). This was introduced as a by-catch ceiling which from 1996 onwards resulted in setting an actual yearly by-catch quota of herring. These by-catch quotas were introduced in 1996 because of very high fishing pressure on the North Sea herring stock in this period.

In July 1996, the herring by-catch rules were tightened up in the EU Member States. Denmark implemented a 10% by-catch limit. In 1999, the (EC) No 1434/98 specifying conditions under which herring may be landed for industrial purposes other than direct human consumption was implemented. Though, Denmark maintained the 10% limit. This national limit was year later adjusted to the EU rules. The EU rules specified 20% herring by-catch in the North Sea (ICES Div. IV) and 10% bycatch in Skagerrak-Kattegat (ICES Div. IIIa). When by-catch ceilings was changed to by-catch quotas in 2013, the by-catch rules were repealed and instead the target species rules according to the technical measures /(EC) No 950/98 was used to limit the by-catches.

In 2015, the landing obligation in EU industrial fisheries was implemented (see below and **Section 3**) and the (EC) No 1434/98 was repealed (see below).

From 1998 onwards, target species and by-catch regulations were introduced in the Danish Norway pout fishery through the establishment of the agreed EU Council and EU-Norway Bilateral Regulation of Fisheries by-catch regulations in the Norway pout fishery (e.g. EU Regulation No 850/98 (EU 1998) – see also section 3 below). Here certain target species minimum percentages were introduced according to the mesh size and mesh type regulations included as well. The by-catch regulations for small meshed fishery (16-31mm in mesh size) in the North Sea stipulated here is that catch retained on board must consist of i) at least 90% of any mixture of two or more target species, or ii) at least 60% of any one of the target species, and no more than 5% of any mixture of cod, haddock, saithe, and no more than 15% of any mixture of certain other by-catch species. These maximum percentages of by-catch species has been in force until 2015 with introduction of the landing obligation regulations (see below and **Section 3**).

According to the Appendix (Bilag) 6 Note (Meddelelse) from October 2012 from the Danish Ministry of Food, Agriculture and Fisheries, according to the general rules set in the Ministry Regulation (Bekendtgoerelse) No. 1222 of 16 December 2011 § 2, it is from 15th October 2012 obligatory for all Danish vessels participating in the targeted Norway pout fishery in the North Sea and Skagerrak-Kattegat to use a 35 mm grid in the small meshed trawl gears used in the fishery (typically with cod-end mesh sizes 16-31 mm). The grid needs to be in accordance with the following technical specifications: Solid grid in steel, plastic, glass fibre or nylon with minimum 35 mm bar width, and the grid has to be mounted in a net section in front of the cod-end where it covers the full cross area of the section and with an opening which allows escapement of fish which cannot pass the grid.

In the Commission Delegated Regulation EU No 1395/2014 of 20 October 2014 establishing a discard plan for certain small pelagic fisheries and fisheries for reduction purposes in the North Sea (http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=uriserv:OJ.L_.2014.370.01.0035.01.ENG). According to this Landing Obligation Regulation implemented from 1st January 2015 the percentage catch composition regulations in the Norway pout fishery were omitted. In the small meshed fishery for reduction purposes targeting industrial or small pelagic species it is not allowed to release or discard catches. All catches – disregarding catch composition – shall be taken on board and be landed. Previous regulations for these fisheries concerning maximum catch composition percentages are accordingly no longer in force (http://naturerhverv.dk/fileadmin/user_upload/NaturErhverv/Filer/Fiskeri/Erhvervsfiskeri/Discardforbud/Vejledning_til_landingsforpligtelsen_-_industri_og_pelagisk_-_Nordsoeen__Skagerrak_og_Kattegat_V1.pdf). However, according to the Danish national management of the Discard Plan under the EU (Danish) TAC-Quota Regulation for 2016 (European Union Newsletter 28th Jan. 2016 (DA) L22/87) then there can with reference to the landing obligation be included only up to 5% of whiting when maximum 9% of the Norway pout quota consists of by-catch of the species covered by Article 15, point 8, in the EU regulation EU/1380/2013.

All these by-catch regulations and gear technical measures and their enforcements have all improved the certainty of the catch composition in the Danish small meshed fishery for reduction purposes conducted in the North Sea and in Skagerrak-Kattegat.

With respect to Norwegian samplings, then the Danish and Norwegian commercial landings sampling procedures of the commercial landings, which vary significantly between the countries, were described in detail in the report of the WGNSSK meeting in September 2004 (ICES WGNSSK (2005) ICES C.M. 2005/ACFM:07). From here it appears that sampling and reporting from Norwegian vessels fishing Norway pout and blue whiting has been slightly changed in 2009 and onwards. Previously, all catch reported as Norway pout included by-catch of other species which was used as input in the assessment. These data was also the basis for the Norwegian official catch statistics reported to among other ICES. The procedure up until 2009 was that if a catch (landing) from a fishing trip consisted of more than 50 % of Norway pout in weight then the full catch consisting of all species was reported as Norway pout for this landing, i.e. by-catch was included in the reported Norway pout catch. In 2009 and onwards, each catch (landing) per trip is evaluated (sorted) according to species, and the actual catch per species for each landing is reported. This increases the precision of the actual catch numbers of Norway pout from Norway. Norway pout caught both in the Norway pout fishery as well as in the blue whiting fishery are from 2009 included in the assessment, and by-catch of other species are excluded. There has not been made an analysis and thorough evaluation of the effect of this change in Norwegian sampling procedure with respect to relative change in the reported catch at age and weight at age. However, the Norwegian assessment experts evaluate that this have only minor effect on the catch at age in number and the weight at age used in the assessment as the by-catch and the actual catch has balanced each other out previously. With respect to effort data, only effort is reported for Norwegian trips with landings consisting of more than 50% Norway pout in weight for 2009 and onwards. Consequently, the procedure in estimating and reporting (average) effort data from Norway (see below) has remained unchanged according to previous years standard procedure for estimating effort data.

A.4. BY-CATCHES IN THE NORWAY POUT FISHERY AND GEAR SELECTIVITY

Fisheries impacts on the ecosystem

During the 1960s a significant small-mesh fishery developed for Norway pout and blue whiting in the northern North Sea. This fishery was characterized by relatively large bycatches, especially of haddock and whiting.

By-catch of herring, saithe, cod, haddock, whiting, and monkfish at various levels in the small meshed fishery in the North Sea and Skagerrak directed towards Norway pout has been documented (e.g. Degel *et al*., 2006, ICES CM 2007/ACFM:35, (WD 22 and section 16.5.2.2)). Especially by-catch of juvenile haddock and cod as well as larger saithe has been in focus. Recent by-catch levels in the Danish and Norwegian small meshed fisheries are given in **Table 1 under Section A.1**. Bycatches of these species have been low in the recent decade, and in general, the by-catch levels of these gadoids have decreased in the Norway pout fishery over the years to a present very low level of by-catch of other species (5-10%). In **Figure 9** below the by-catch and relative species distribution is shown as proportion of Norway pout, haddock and whiting in the in the Danish and Norwegian small-meshed fisheries for reduction purposes targeting Norway pout in the North Sea for the period 1974 to 2005 as estimated in 2007 (data from ICES 2007). Furthermore, **Table 5** below gives by-catch levels in 2002-2005 by species in Danish and Norwegian small meshed industrial trawl fishery in the North Sea and Skagerrak areas targeting Norway pout. For Norway, the landings used for consume purposes in the small meshed fishery can only be allocated to industrial fishery for the last two years in this period.

The Danish fishery has historically used two types of trawls which gives significantly different catch rates and of Norway pout and herring. Some fishermen conduct a rather clean Norway pout fishery where they use more wide trawl gears with lower gap (trawl opening height) where they catch more Norway pout and only very few herring. Other fishermen conduct a more mixed fishery targeting Norway pout and herring where they use more pelagic trawl types with larger gap and less wideness which are more efficient towards herring.

With the aim of protecting other species (cod, haddock, saithe, whiting, and herring as well as mackerel, monkfish, squids, flatfish, gurnards, *Nephrops*) a row of management measures are in force for the small meshed fishery in the North Sea such as the area closures, by-catch regulations (by-catch quotas of herring and maximum by-catch percentages for gadoids and herring), minimum mesh size, selective grids/panels in the small meshed gears, and minimum landing size as described under regulations below in section 3. Technical measures to protect the above mentioned bycatch species have been maintained or improved in the directed Norway pout fishery.

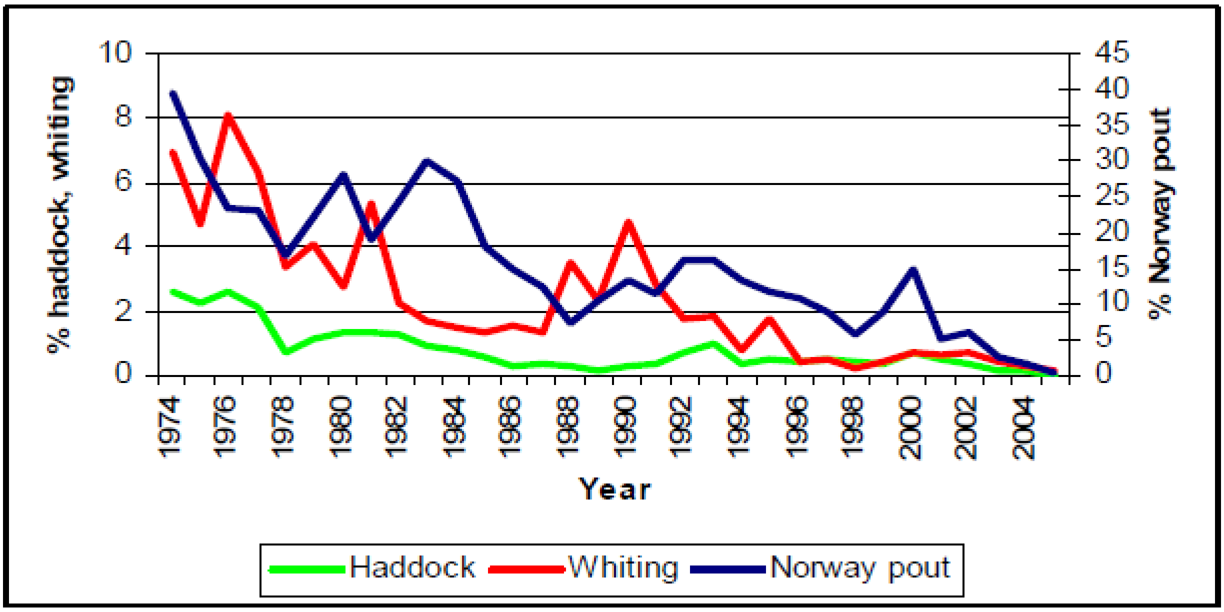


Figure 9. Proportion of Norway pout, haddock and whiting in the in the Danish and Norwegian small-meshed fisheries in the North Sea for the period 1974-2005. (From EU 2007 based on data from ICES in 2007).

Table 5. Landings (tons) per species in the Danish small meshed Norway pout fishery in the North Sea by year and quarter. Landings are divided into the part used for reduction purposes and the part used for human consumption purposes. The latter landings are included in catch in numbers of human consumption landings.

Year	Species	Purpose	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Blank	Total	% of total catch
2005	Norway pout	Reduction						0	0
2004		Reduction	504		1474	5877		7855	87.5
2003		Reduction		45	1556	6322		7923	87.8
2002		Reduction	2,546		5,603	25,567	9,508	43224	78.6
2005	Blue whiting	Reduction						0	0
2004		Reduction	66					66	0.73
2003		Reduction		19	23	8		50	0.55
2002		Reduction	1966		589	950	1171	4676	8.50
2005	Herring							0	0
2004			11		422	304		737	8.21
2003				1	113	222		336	3.73
2002					217	2337	639	3193	5.81
2005	Cod	Reduction						0	0
		Hum. Con.						0	0
2004		Reduction				1		1.3	0.01
		Hum. Con.	0.3		0.2	0.3		0.8	0.01
2003		Reduction				3		3	0.03
		Hum. Con.			0.5	0.8		1.3	0.01
2002		Reduction				3		3	0.01
		Hum. Con.	2		15.4	22.7		40.1	0.07
2005	Haddock	Reduction						0	0
		Hum. Con.						0	0
2004		Reduction	5		49	3		57	0.63
		Hum. Con.	0.2		0.2	0.5		0.9	0.01
2003		Reduction				16		16	0.18
		Hum. Con.			0.1	1.8		1.9	0.02
2002		Reduction			408	1137		1545	2.81
		Hum. Con.	0.7		4.3	9.8		14.8	0.03
2005	Whiting	Reduction						0	0
		Hum. Con.						0	0
2004		Reduction	32		59	141		232	2.58
		Hum. Con.	0.4		0.3	0.2		0.9	0.01
2003		Reduction			51	214		265	2.94
		Hum. Con.			0.3	2		2.3	0.03
2002		Reduction			239	1436		1675	3.05
		Hum. Con.			5.4	5.5		10.9	0.02
2005	Saithe	Reduction						0	0
		Hum. Con.						0	0
2004		Reduction						0	0
		Hum. Con.	0.7		5.8	4.2		10.7	0.12
2003		Reduction		0.4	4	22.8		27.2	0.30
		Hum. Con.						0	0
2002		Reduction			45	201		246	0.45
		Hum. Con.	30		84.3	66.3		180.6	0.33
2005	Other human	Hum. Con.						0	0
2004	Cons. Species	Hum. Con.	0.9		2.7	2.5		6.1	0.07
2003		Hum. Con.		0.6	2.2	6.2		9	0.10
2002		Hum. Con.						0	0
2005	All species	All						0	0
2004		All	626		2023	6331		8980	100
2003		All		66	2025	6929		9020	100
2002		All	4511		6815	31887	11767	54980	100

Gear Selective Devices to Reduce By-Catch

Review of scientific documentation show that gear selective devices can be used in the Norway pout fishery, significantly reducing by-catches of juvenile gadoids, larger gadoids, and other non-target species (Eigaard and Holst, 2004; Nielsen and Madsen, 2006, ICES CM 2007/ACFM:35, WD 23 and section 16.5.2.2; Eigaard and Nielsen, ICES CM2009/M:22; Eigaard, Hermann and Nielsen, 2012). Sorting grids are at present used in the Norwegian and Danish fishery (partly implemented as management measures for the larger vessels), but modification of the selective devices and their implementation in management is ongoing.

From 2010 grids have been used in the Norwegian fishery. From 15th October 2012 it has been obligatory for all Danish vessels participating in the targeted Norway pout fishery in the North Sea and Skagerrak-Kattegat to use a 35 mm grid in the small meshed trawl gears used in the fishery (typically with cod-end mesh sizes 16-31 mm). The introduction of the sorting grid in the Danish fishery (see below) has lead to a reduction in catch rates of 5-10%. The grid reduced the bycatch of gadoids by around 50% in biomass, but it remains difficult to avoid small gadoids (Eigaard et al. 2012); it also resulted in a reduction of herring bycatch. For the Norwegian fishery, area closures have had an effect on reducing by-catches in the combined Norway pout and blue whiting fishery. Introduction of selective grids in the Norwegian trawls used for this fishery has furthermore had an effect on bycatches, but some vessels do not always use this grid in the fishery (not mandatory in a part of the fishery).

Existing technical measures such as the closed Norway pout box, minimum mesh size in the fishery, and by-catch regulations to protect other species have been maintained.

Studies on selectivity in the Norway pout fishery

Early Scottish and Danish attempts to divide haddock, whiting and herring from Norway pout by using separator panels, square mesh windows, and grids were all relatively unsuccessful. More recent Faeroese experiments with grid devices have been more successful. A 74 % reduction of haddock was estimated (Zachariassen and Hjalti, 1997) and 80% overall reduction of the by-catch (Anon., 1998).

Investigations of gear specific selective devices and gear modifications to reduce un-wanted by-catch in the small meshed Norway pout fishery in the North Sea and Skagerrak have been made during sea trials in year 2000 and reported through an EU Financed Project (EU, 2002), and the results from here have been followed up upon in a scientific paper from DIFRES and CONSTAT, DK (Eigaard and Holst, 2004). Previous investigations of size selective gear devices in the Norway pout trawl fishery in the North Sea was performed by IMR Norway during sea trials in 1997-1999 also published in a scientific paper (Kvalsvik *et al*., 2006), as well as in a number of other earlier studies on the issue. Main results of previous investigations have been reviewed and summarized in Working Document No. 23 to the WGNSSK (2006) by *Nielsen and Madsen (2006)*.

Danish-Norwegian fishing trials and pilot investigations were performed in autumn 2005 in order to explore by-catch- levels in the small meshed industrial trawl fishery in the North Sea targeting Norway pout. The results are given in Working Document No. 22 to the WGNSSK (2006) by *Degel, Nedreaas and Nielsen (2006)*. The results were noisy and showed variable by-catch levels for different species. The investigations indicated spatio-temporal differences in catch levels by species in the commercial small meshed fishery for Norway pout as well as an effect of targeting and use of fishing method on the by-catches. However, these patterns are only based on results from pilot investigations. Existing logbook data and knowledge about spatio-temporal patterns in catch rates of target species and by-catch species in the fishery are at present not adequate and with high enough spatial and temporal resolution to implement management measures with respect to regulations on spatio-temporal allocation of fishing effort to reduce by-catches. With regard to diurnal differences in the catch rates of Norway pout and by-catches of other species, the few pilot investigation results indicated significant lower by-catch of Blue whiting during night hauls.

Eigaard and Holst (2004) and EU (2002) found that when testing a trawl gears with a sorting grid with a 24 mm bar distance in combination with a 108 mm (nominal) square mesh window through experimental, commercial fishery the results showed improved selectivity of the commercial trawl with catch weight reductions of haddock and whiting of 37 and 57%, but also a 7 % loss of Norway pout. The study showed that application of these reduction percentages to the historical level of industrial by-catch in the North Sea lowered on average the yearly haddock by-catch from 4.3 to 2.7% of the equivalent spawning stock biomass. For whiting the theoretical reduction was from 4.8 to 2.1%. The purpose of the sorting grid was to remedy the by-catch of juvenile gadoids in the industrial fishery for Norway pout, while the purpose of square mesh window was to retain larger marketable consume fish species otherwise sorted out by the grid. By-catches in this study was mainly evaluated for haddock, whiting and cod, i.e. not for all above mentioned by-catch species of concern in the Norway pout fishery. However, the experiments have shown that the by-catch of important human consumption species in the industrial fishery for Norway pout can be reduced substantially by inserting a grid system in front of the cod-end. The study also demonstrated that it is possible to retain a major part of the larger marketable fish species like whiting and haddock and at the same time maintain substantial reductions of juvenile fish of the same species. The study finally gave clear indications that further improvement of the selectivity is possible. This can be obtained by adjusting the bar distance in the grid and the mesh size in the selective window, but further research would be necessary in order to establish the optimal selective design.

The results reported in Kvalsvik *et al*. (2006) include results for more species of concern in the Norway pout fishery. They carried out experimental fishing with commercial vessels first testing a prototype of a grid system with different mountings of guiding panel in front of the grid and with different spacing (25, 22 and 19 mm) between bars, and then, secondly, testing if the mesh size in the grid section and the thickness of the bars influenced the selectivity of the grid system. Two different mesh sizes and three different thicknesses of bars were tested. Based on the first experiments, only a bar space of 22mm were used in the later experiments. These showed respectively that a total of 94.6% (weight) of the by-catch species was sorted out with a 32.8% loss of the industrial target species, where the loss of Norway pout was around 10%, and respectively that 62.4% of the by-catch species were sorted out and the loss of target species was 22%, where the loss of Norway pout was around 6%. When testing selectivity parameters for haddock, the main by-catch species, the parameters indicated a sharp size selection in the grid system.

In conclusion, the older experiments indicate that there is no potential in using separator devices and square mesh panels. Recent and comprehensive experiments with grid devices indicate a loss of Norway pout at around 10% or less when using a grid with a 22-24 mm bar distance. It is also indicated that there is a considerable loss of other industrial species being blue whiting, Argentine and horse mackerel. A substantial by-catch reduction of saithe, whiting, cod, ling, hake, mackerel, herring, haddock and tusk have been observed. The reduction in haddock by-catch is, however, lowered by the presence of smaller individuals. The Danish experiment indicates that it is possible to retain larger valuable consume fish species by using a square mesh panel in combination with the grid. Selectivity parameters have been estimated for haddock, whiting and Norway pout. These can be used for simulation scenarios including estimates of the effect of changing the bar distance in the grid. Selectivity parameters for more by-catch species would be relevant. However, the grid devices have shown to work for main by-catch species. A general problem encountered by implementing sorting grids in industrial fisheries is the very large catches handled. Durability and strength of the grid devices used under fully commercial conditions are consequently very important and needs further attention. Furthermore, handling of heavy grid devices can be problematic from some vessels. Grid devices are, nevertheless, used in most shrimp fisheries, where catches often are large.

Sorting grids in combination with square mesh panels have been shown to reduce bycatches of whiting and haddock by 57% and 37%, respectively (Eigaard and Holst, 2004; Nielsen and Madsen 2006 (ICES CM 2006/ACFM:35); Eigaard and Nielsen, 2009).

The most recent study on by-catch reduction by use of selective devices in the Danish Norway pout fishery is published in Eigaard, Hermann and Nielsen 2012. Here a lightweight sorting grid was developed to reduce bycatch in the Danish small-meshed trawl fishery (22 mm full mesh in the cod end) for Norway pout in the North Sea. Experimental fishing with the grid demonstrated the possibility to capture Norway pout with only a minimum of unintended bycatch. Fishing with two different grid orientations, backwards and forwards-leaning, in distinct day and night hauls, resulted in an estimated release of between 88.4 and 100% of the total number of haddock (*Melanogrammus aeglefinus*) and whiting (*Merlangius merlangus*) entering the trawl.

However, bycatch reductions were not significantly different between day and night or between grid orientations, indicating that the grid rejection of haddock and whiting is not influenced by fish behaviour. The loss of the target species, Norway pout, was low(between 5.6% and 13.7%) in comparison with the bycatch excluded, and clearly length dependent. Consequently, loss of target species would vary with the size structure of the population fished. Although results were not statistically significant, length-based analyses indicated that the grid rejection likelihood for particularly smaller Norway pout (<16 cm) was higher when fishing with the forwards-leaning grid during the night; this might be explained by behavioural and visual aspects of the fish-grid encounter process for Norway pout.

A.5. DISCARD OF NORWAY POUT IN FISHERIES FOR CONSUME PURPOSES

Discard levels of Norway pout in international fisheries are low as shown in **Table 6** and **Figure 10**. It should be noted that Norway is not conducting discard sampling because of their discard ban, so the discard of Norway pout in Norwegian fisheries are not known. This is the case for both Norwegian fisheries for consume purposes and small meshed fisheries for reduction purposes. With respect to the latter there are in general no discarding in the small meshed fisheries for reduction purposes in Denmark and Norway.

Norway pout is only caught in small meshed fisheries for reduction purposes conducted by Denmark and Norway with typically 16-31 mm mesh size in the trawl cod end (i.e. the DEF_16-31_0_0 or DEF_16-31_2_35 or DEF_16-31_X_X metiers) or in crustacean (shrimp and Nephrops) fisheries in the northern North Sea or in Skagerrak conducted by several countries. **Table 6** gives an overview of discard of Norway pout by year, metier and country during the period 2002-2015 based on imported data from InterCatch August 2016. The discard data covers fisheries for human consumption purposes, which mainly are crustacean fisheries, as there is no discard of Norway pout in small meshed fisheries (metiers) for reduction purposes conducted by Denmark and Norway. Other countries do not have small meshed fisheries for Norway pout or do not sample them. Because of the discard ban there is no discard tabulated for the Norwegian fisheries. **Figure 10** gives an overview of absolute (tons) and relative (%) proportion between discard of Norway pout in fisheries for human consumption purposes and the total landings of Norway pout in the small meshed fisheries for reduction purposes (with no discard in the latter) divided by year in the period 2002-2014. The total landings data originates from the ICES evaluated total landings of Norway pout by year as presented in the September 2015 Norway pout assessment in the ICES WGNSSK Report 2015.

Table 6. Discard of Norway pout by year, metier and country for the period 2002-2015 based on imported data from InterCatch August 2016. The discard data covers fisheries for human consumption purposes as there is no discard of Norway pout in small meshed fisheries (metiers) for reduction purposes. Because of a discard ban there is no discard in Norwegian fisheries.

Row Labels	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
FPO_CRU_0_0_0_all													0	
Sweden													0	
GNS_DEF_>=220_0_0_all												0	0	0
Denmark												0	0	0
GNS_DEF_100-119_0_0_all												0	0	0
Denmark												0	0	0
GNS_DEF_120-219_0_0_all					0			0	0	0	0	0	0	0
Denmark					0			0	0	0	0	0	0	0
GNS_DEF_120-219_0_0_all_FDF							0	0		0	0	0	0	0
Denmark							0	0		0	0	0	0	0
GTR_DEF_all_0_0_all										0				
UK (England)										0				
MIS_MIS_0_0_0_HC	0	1	2	0	1	0	0	1	1	0	1	0	3	0
Denmark	0	1	2	0	1	0	0	1	1	0	1	0	3	0
Sweden													0	
MIS_MIS_0_0_0_IBC									0					
Sweden									0					
OTB_CRU_32-69_0_0_all	472	26		62			153	625	943	301	136	109	106	183
Denmark	472	26						246	206	36	60	81	55	64
Sweden				62			153	379	738	265	76	28	51	119
OTB_CRU_32-69_2_22_all				3			26	165	105	2	6	26	12	48
Sweden				3			26	165	105	2	6	26	12	48
OTB_CRU_70-89_2_35_all	3	5	1	0			0	1		0	3	0	0	0
Denmark	3	2	1	0										
Sweden		3	0	0			0	1		0	3	0	0	0
OTB_CRU_70-99_0_0_all	4	0	9	28	7	9	4	2027	996	1807	339	55	79	119
Denmark	1	0	1	11			0		0	0	0	0		0
UK (England)	3	0	8	17	7	9	4	8	2	2	5	3	11	11
UK(Scotland)								2019	995	1805	333	53	68	108
OTB_CRU_70-99_0_0_all_FDF										0				
Denmark										0				
OTB_CRU_90-119_0_0_all	9	4	20	17	29	5	13	25	62	32	11	15	1	5
Denmark	9	2	20	15	29	5	8	21	62	30	11	12	1	3
Sweden		1	0	2			4	5	1	1	0	3	0	2
OTB_CRU_90-119_0_0_all_FDF							0	0	0	1	0	0	0	0
Denmark							0	0	0	1	0	0	0	0
OTB_DEF_>=120_0_0_all	29	21	90	23	15	3	24	160	103	188	20	341	168	75
Denmark	28	20	90	23	15	3	22	6	23	6	2	5	1	2
UK (England)	1	0	1	0		0	2	0	0	0	0			0
UK(Scotland)								154	80	182	18	336	167	73
OTB_DEF_>=120_0_0_all_FDF							0	0	6	3	5	4	8	1
Denmark							0	0	6	3	5	4	8	1
UK(Scotland)								0	0	0	0	0	0	0
OTB_DEF_70-99_0_0_all					0	1	0			1				
UK (England)					0	1	0			1				
SDN_DEF_>=120_0_0_all	0	0	0	0	1	0	0	0	0	0	0	0	0	1
Denmark	0	0	0	0	1	0	0	0	0	0	0	0	0	1
SDN_DEF_>=120_0_0_all_FDF							0	0		0	0	0	0	0
Denmark							0	0		0	0	0	0	0
SSC_DEF_>=120_0_0_all	0	0		0				0				0	0	0
Denmark	0	0		0				0				0	0	0
SSC_DEF_>=120_0_0_all_FDF										0				
Denmark										0				
TBB_CRU_16-31_0_0_all								1	0	0	0	0	0	0
Denmark								1	0	0	0	0	0	0
UK (England)													0	
TBB_DEF_>=120_0_0_all	0	0												
Denmark	0	0												
TBB_DEF_90-99_0_0_all	0													
Denmark	0													
Grand Total	516	57	123	133	53	18	221	3006	2216	2336	522	552	376	431

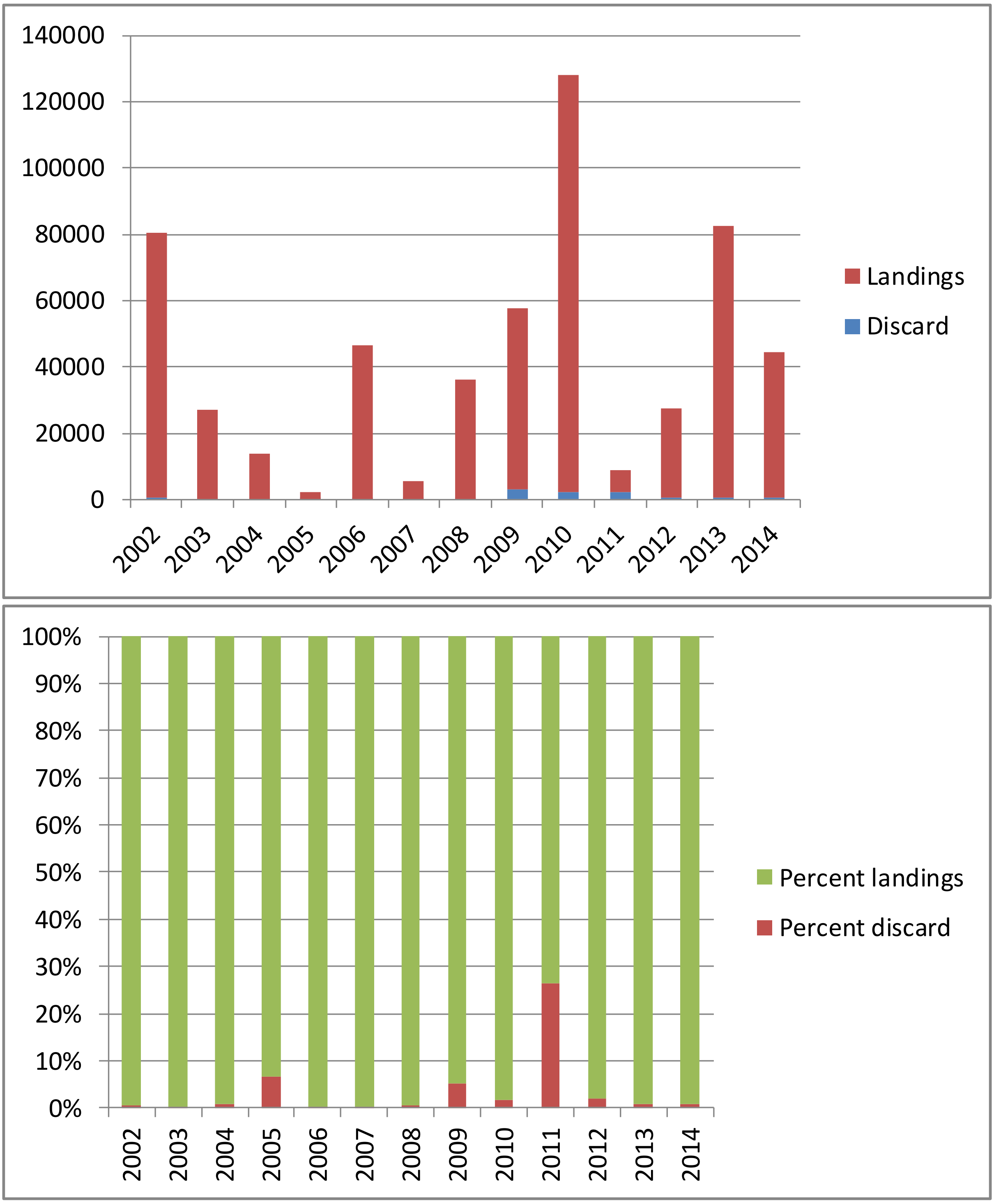


Figure 10. Absolute (tons) and relative (%) proportion between discard of Norway pout in fisheries for human consumption purposes and the total landings of Norway pout in the small meshed fisheries for reduction purposes (with no discard in the latter) divided by year in the period 2002-2014. The total landings data originates from the ICES evaluated total landings of Norway pout by year as presented in the September 2015 Norway pout assessment in the ICES WGNSSK Report 2015.

A.6. Commercial fishery efficiency by year, quarter, metier and vessel category

Denmark, Sweden, Germany, Faroe Islands and UK (England-Wales, Scotland, N. Ireland) provide catch and effort data to the ICES InterCatch Database in standardized format for the stock and fishery, and Norway, France, Netherlands, and Belgium has from 2016 reported their catch and effort in InterCatch as well in standardized format by metier.

In **Figures 11-21** the Danish commercial fishery efficiency in form of catch rates (catch per unit of effort, CPUE) in tonnes per fishing days for the Danish commercial Norway pout fishery are shown. This also include normalized catch rates to long term averages as an indicator of changes in catch efficiency over time from 1987-2015 of the different metiers as well as differences in catch efficiency between vessel categories (engine horse power classes) and between different seasons (quarters) of year.

The analysed CPUE data cover all Danish metiers fishing Norway pout, and all fishing trips where the catch composition in the landings (catches) have consisted of 70% or more of Norway pout. In **Figure 11** the catches from the total Danish Norway pout fishery during the period 1987-2015 is shown by ICES statistical rectangle. It appears from here that the main Danish Norway pout fishery during this period has been conducted in the rectangles 45E9, 46E9, 47E9, 45F0, 46F0, 47F0, 45F1, 46F1, and 47F1 which among other includes the Fladen Ground area. In **Figures 12-21** the catch efficiency of the Danish fishery from those squares are included (shown).

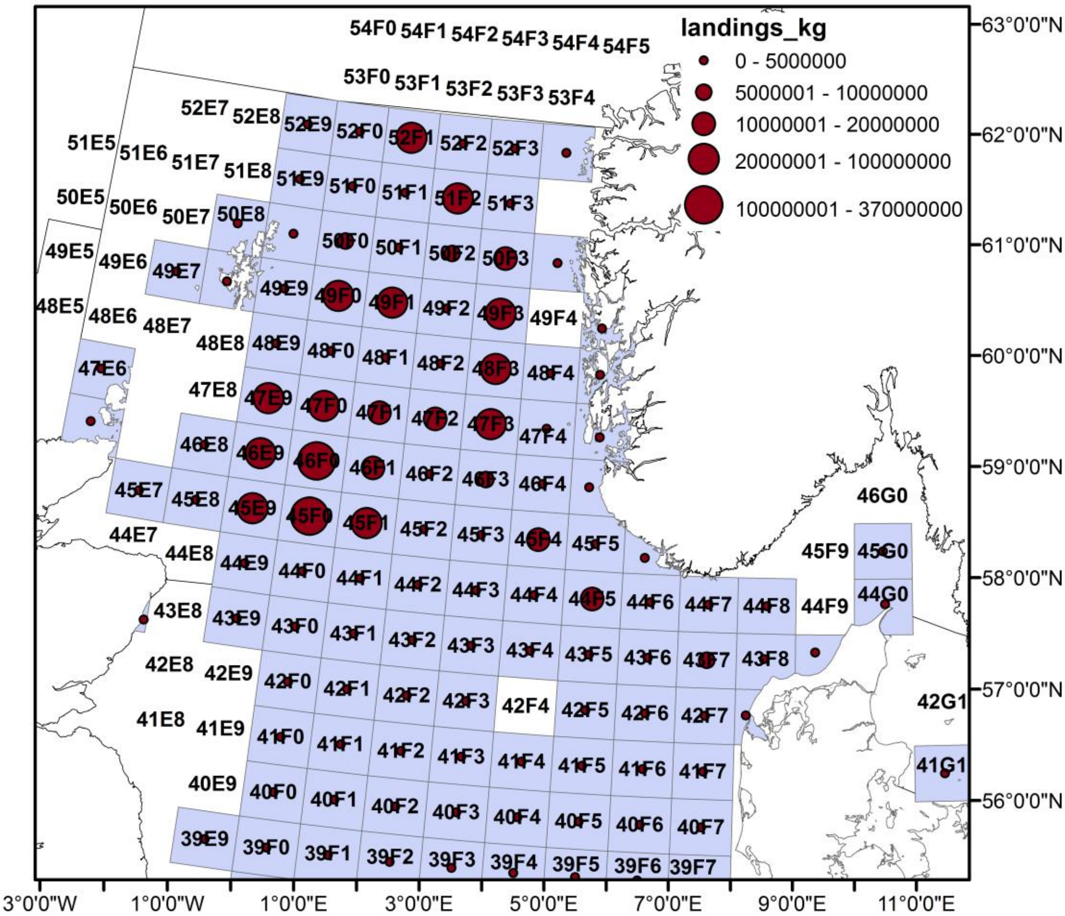


Figure 11. Distribution of the total Danish Norway pout catches during the period 1987-2015 by ICES statistical rectangle.

Commercial fishery catch per unit of effort by year, quarter, metier and vessel category:

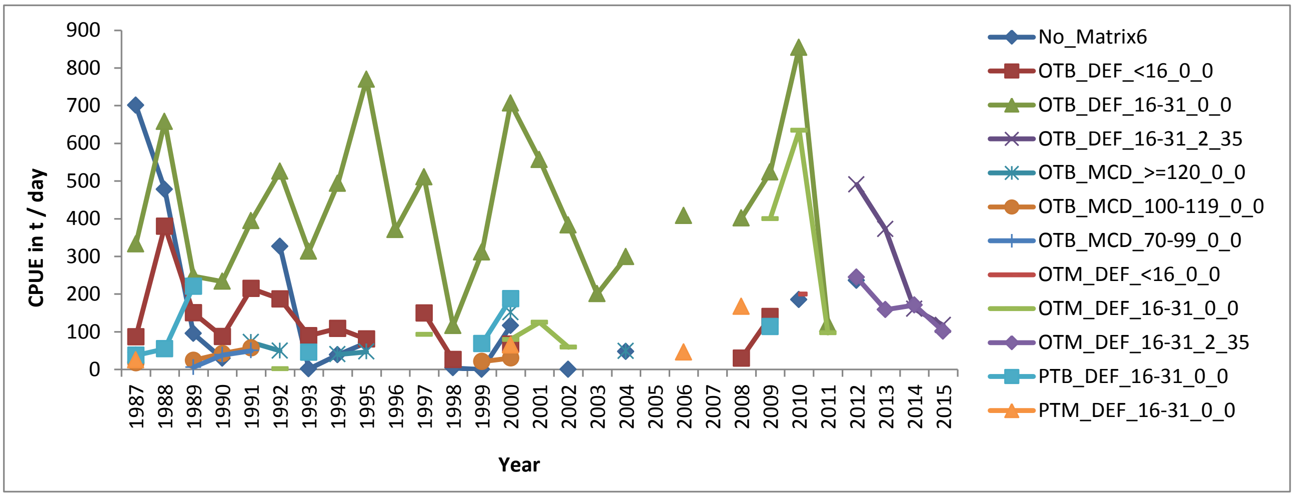


Figure 12. Norway pout in IV and IIIa. Catch per unit of effort (CPUE) by metier in tonnes per fishing day per year for the Danish fishing fleet. The CPUE covers trips where more than 70% of the landings were Norway pout, and it covers all metiers fishing Norway pout.

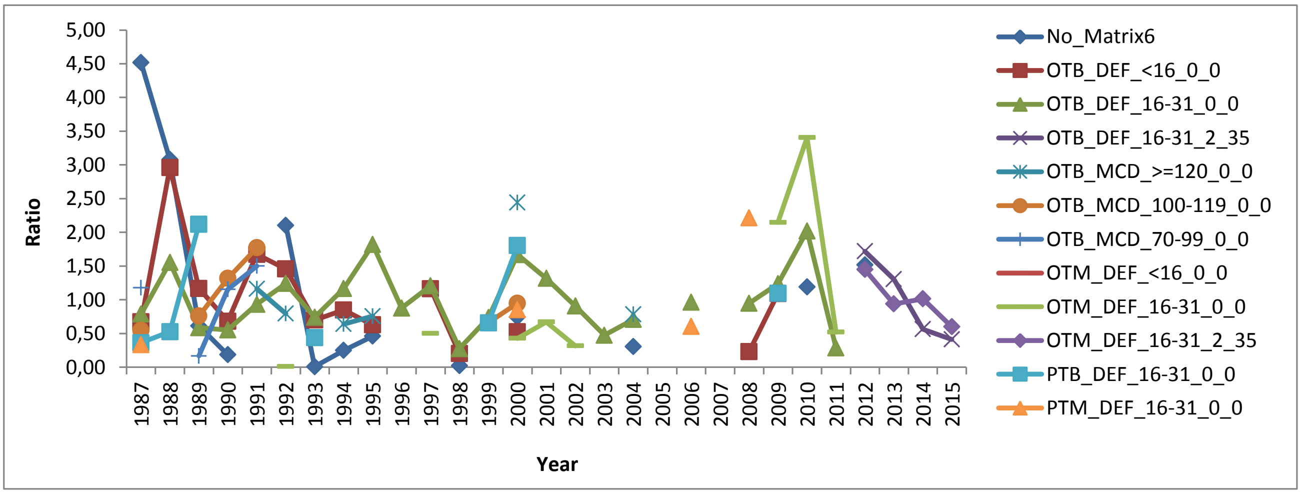


Figure 13. Norway pout in IV and IIIa. Catch per unit of effort (CPUE) by metier normalized to long term average per year for the Danish fishing fleet. The CPUE covers trips where more than 70% of the landings were Norway pout, and it covers all metiers fishing Norway pout.

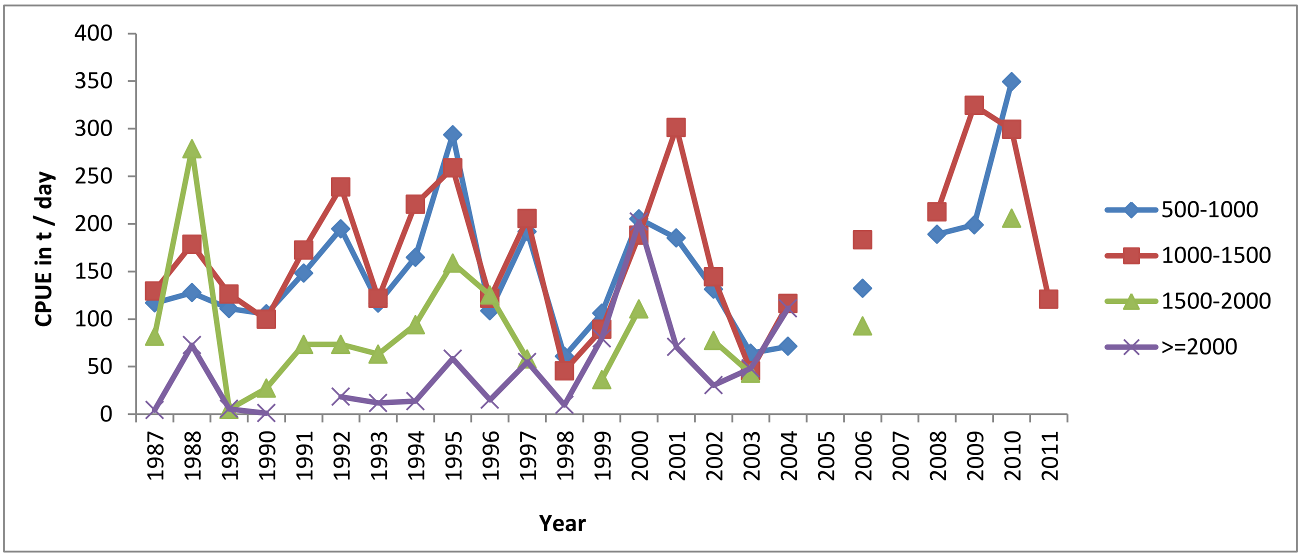


Figure 14. Norway pout in IV and IIIa. Catch per unit of effort (CPUE) by engine horse power (hp) class in tonnes per fishing day per year for the Danish fishing fleet. The CPUE covers trips where more than 70% of the landings were Norway pout, and it covers the metier OTB_DEF_16-31_0_0 only (main metier fishing Norway pout up to 2011).

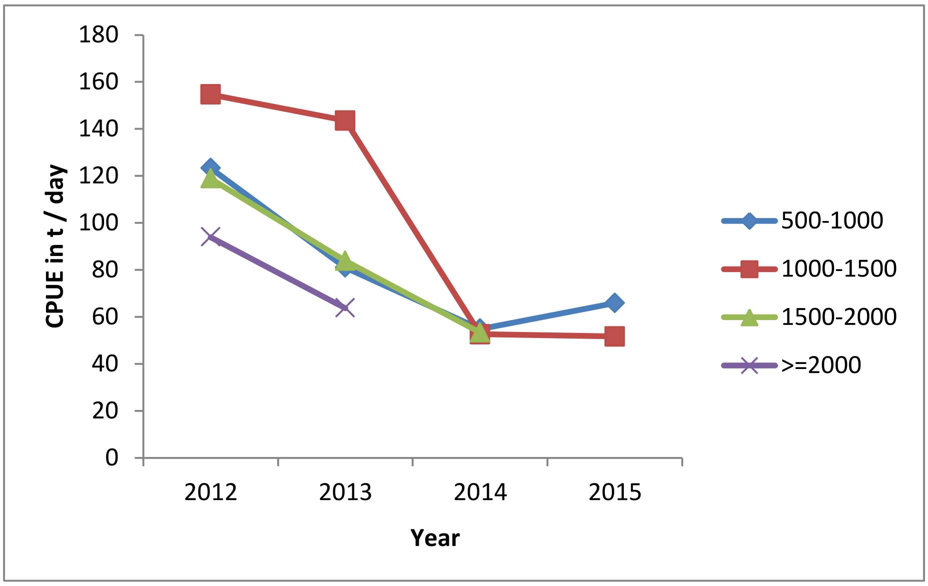


Figure 15. Norway pout in IV and IIIa. Catch per unit of effort (CPUE) by engine horse power (hp) class in tonnes per fishing day per year for the Danish fishing fleet. The CPUE covers trips where more than 70% of the landings were Norway pout, and it covers the metier OTB_DEF_16-31_2_35 only (main metier fishing Norway pout from 2012 onwards).

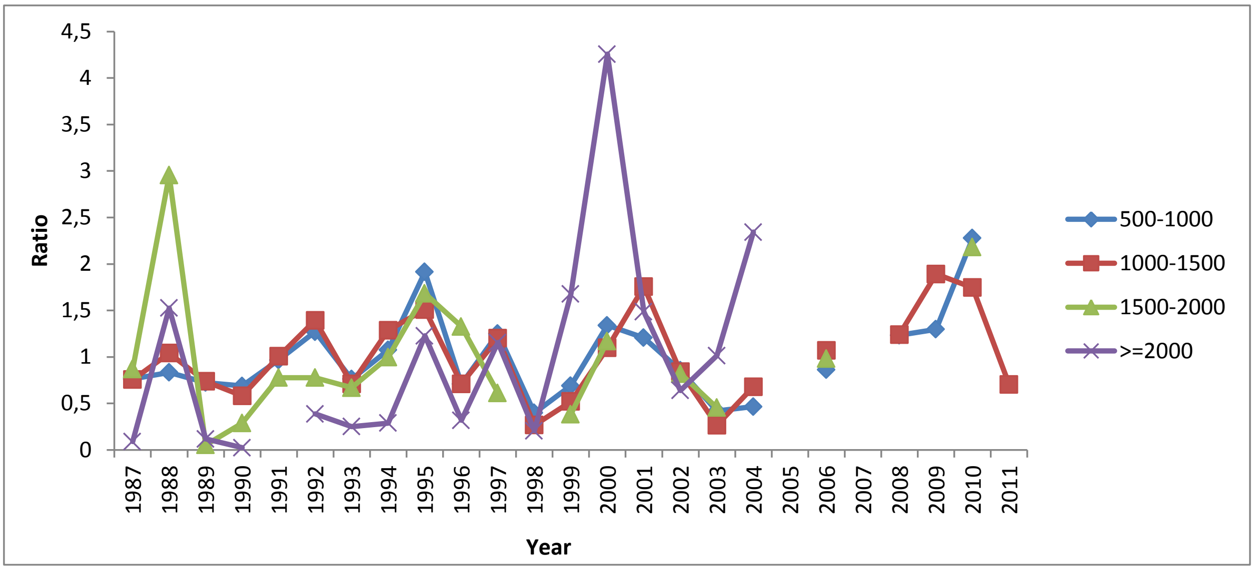


Figure 16. Norway pout in IV and IIIa. Catch per unit of effort (CPUE) by horse power (hp) group normalized to long term average per year for the Danish fishing fleet. The CPUE covers trips where more than 70% of the landings were Norway pout, and it covers the OTB_DEF_16-31_0_0 metier (main metier 1987-2011).

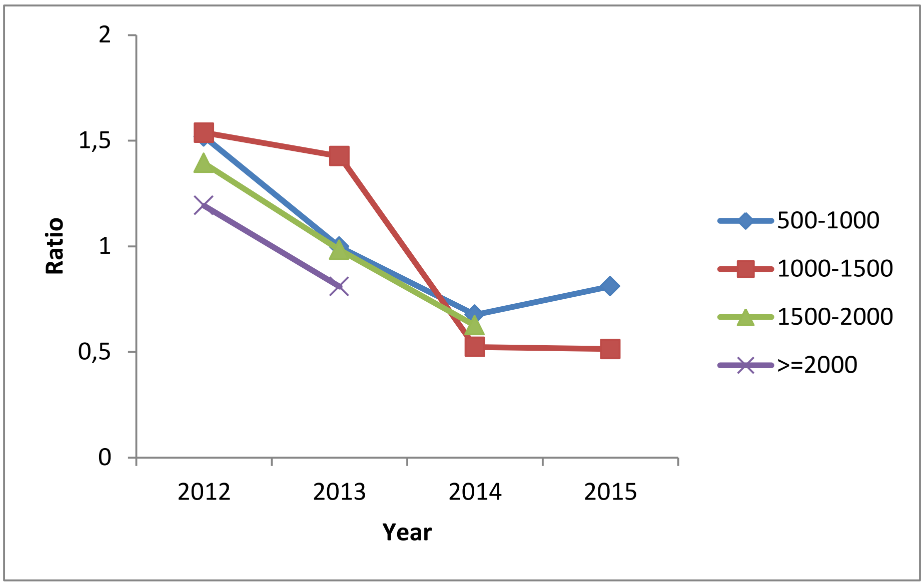


Figure 17. Norway pout in IV and IIIa. Catch per unit of effort (CPUE) by horse powr (hp) group normalized to long term average per year for the Danish fishing fleet. The CPUE covers trips where more than 70% of the landings were Norway pout, and it covers the OTB_DEF_16-31_2_35 metier (main metier 2012 onwards).

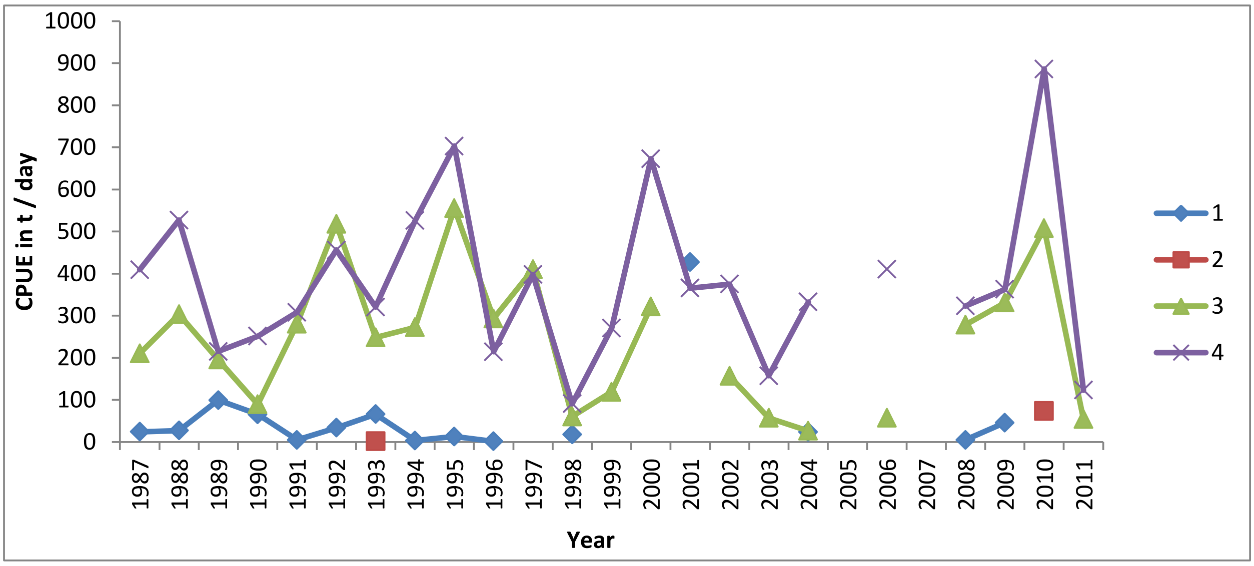


Figure 18. Norway pout in IV and IIIa. Catch per unit of effort (CPUE) by quarter of year (1-4) in tonnes per fishing day per year for the Danish fishing fleet. The CPUE covers trips where more than 70% of the landings were Norway pout, and it covers the metier OTB_DEF_16-31_0_0 only (main metier fishing Norway pout up to 2011).

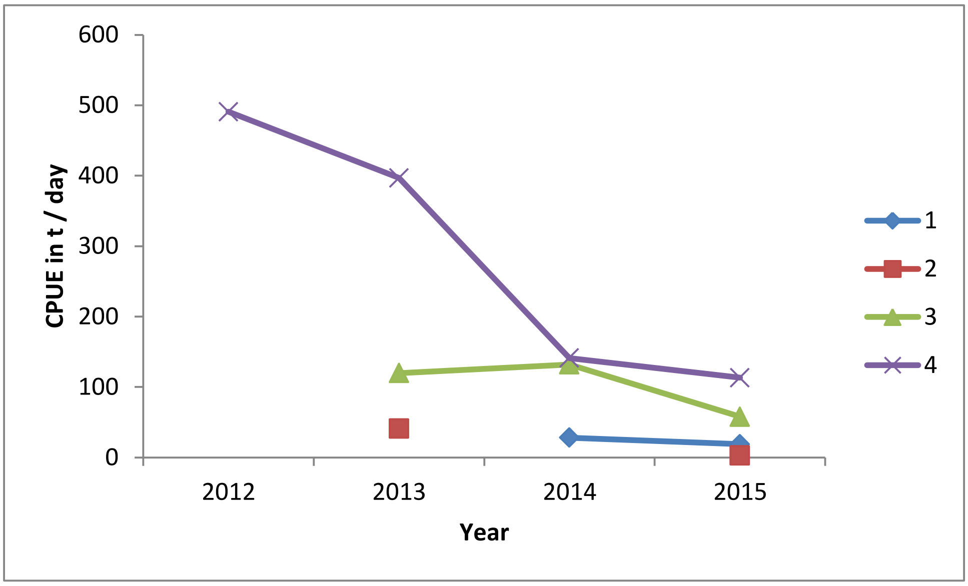


Figure 19. Norway pout in IV and IIIa. Catch per unit of effort (CPUE) by quarter of year in tonnes per fishing day per year for the Danish fishing fleet. The CPUE covers trips where more than 70% of the landings were Norway pout, and it covers the metier OTB_DEF_16-31_2_35 only (main metier fishing Norway pout from 2012 onwards).

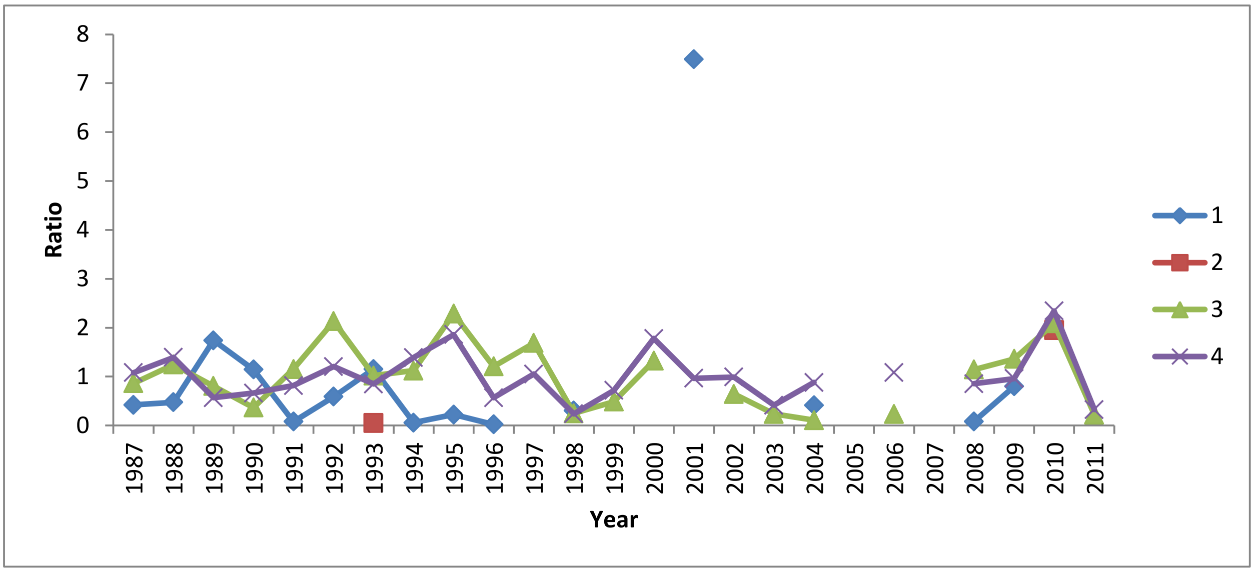


Figure 20. Norway pout in IV and IIIa. Catch per unit of effort (CPUE) by quarter of year normalized to long term average per year for the Danish fishing fleet. The CPUE covers trips where more than 70% of the landings were Norway pout, and it covers the OTB_DEF_16-31_0_0 metier (main metier 1987-2011).

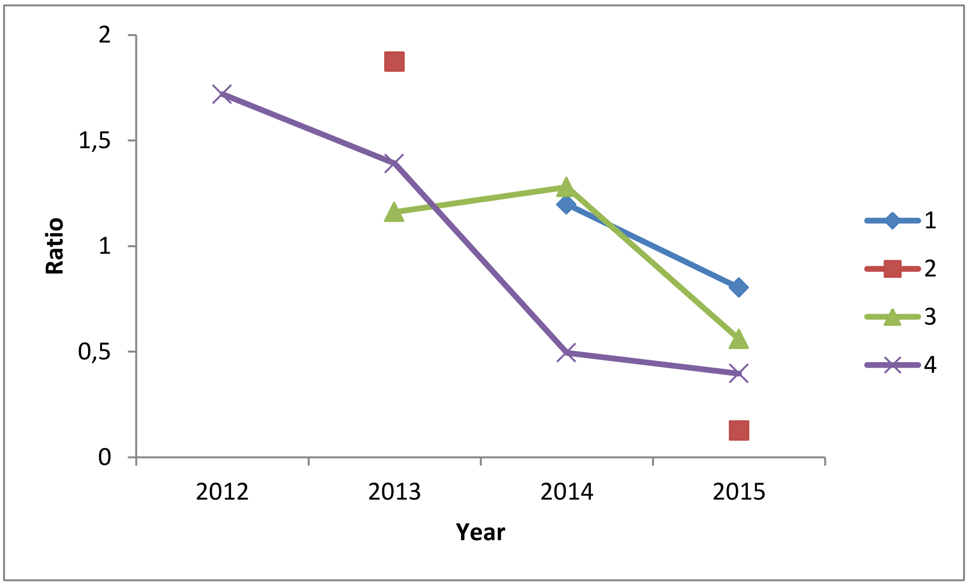


Figure 21. Norway pout in IV and IIIa. Catch per unit of effort (CPUE) by quarter of year normalized to long term average per year for the Danish fishing fleet. The CPUE covers trips where more than 70% of the landings were Norway pout, and it covers the OTB_DEF_16-31_2_35 metier (main metier 2012 onwards).

A.7 COMMERCIAL CATCH AND EFFORT FISHERY DATA USED IN THE ASSESSMENT UP TO 2016

The SXSA seasonal assessment used up to August 2016 the combined catch and effort data from the commercial Danish and Norwegian small meshed trawler fleets fishing mainly in the northern North Sea in selected fishing areas of the total fishing area. Inclusion and exclusion of this commercial tuning fleet in the assessment was tested with the SXSA model during exploratory assessment runs at the May 2016 and August 2016 benchmark assessment (ICES WKPOUT 2016) as well as with exploratory runs with the seasonal SAM, SESAM, model during the August 2016 benchmark assessment (ICES WKPOUT 2016).

Combined CPUE indices by age and quarter for the Danish and Norwegian commercial fishery tuning fleet (including data up to 2006) is calculated from effort data obtained from the method of effort standardization of the commercial fishery tuning fleet described below and vessel category specific catches by area. CPUE is estimated on a quarterly basis for the Danish and Norwegian commercial fleets.

The resulting combined, commercial fishery CPUE data by age and quarter is presented in the input data to the yearly performed assessment. The commercial fleet data (up to 2006) are used in tuning of the assessment based on the combined and standardized Danish and Norwegian effort data and on the catch data for the commercial fishery

Commercial fishery tuning fleets:

In addition to the analyses of the commercial fishery assessment tuning fleet (including data up to 2006) as described above (effort standardization) the quarterly CPUE indices of the commercial fishery tuning fleet were analysed during the 2004 benchmark assessment:

1. The indices for the 0-group in 3rd quarter of the year have been excluded from the commercial fishery tuning fleet. The main argumentation for doing that is that this age group indicate clear patterns in trends in catchability over the assessment period as shown in the single fleet/quarter assessment runs in section 12.3 (Figure 12.3.7), ICES WGNSSK (2005). Secondly, there is no correlation between the commercial fishery 3rd quarter 0-group index and the commercial fishery 4th quarter 0-group index, and no correlation between the 3rd quarter commercial fishery 0-group index in a given year with the 1-group index of the 3rd quarter commercial fishery the following year.
2. The 2nd quarter indices for all age groups have been excluded from the commercial fishery tuning fleet. This is mainly because of indications of strong trends in catchability over time in the assessment period for this part of the tuning fleet for all age groups as indicated by single fleet tuning runs in the section 12.3 (Figure 12.3.7), ICES WGNSSK (2005). Also, the within quarter and between quarter correlation indices are in general relatively poor. The cohorte analyses of the 2nd quarter commercial fishery indices indicate as well relative changes over time.

For an overview of the time series included and used by year and age in the assessment see **Table 7** below.

Commercial fishery tuning fleet up until 2006

Background descriptions of the commercial fishery tuning series used (including data up to 2006) from the commercial fishery are given in the 2004 working group report (ICES WGNSSK (2005) ICES CM 2005/ACFM: 07) and the 1996 working group report (ICES CM 1997/Assess:6). The Danish catch and effort data covers the main Danish fishing grounds in the Northern North Sea including the Fladen Ground (North-Area-2) - see **Figure 11** above.

Standardized effort data for both the Norwegian and Danish commercial fishery vessels are included in the assessment commercial fishery tuning fleet up until 2006.

Method of effort standardization of the commercial fishery tuning fleet

Results and parameter estimates by period from the yearly regression analysis on CPUE versus GRT for the different Danish vessel size categories are used in the effort standardization of both the Norwegian and Danish commercial fishery vessels included in the assessment tuning fleet with data up until 2006.

Background descriptions of the commercial fishery tuning series used (including data up to 2006) and methods of effort standardization of the commercial fishery between different vessel size categories and national commercial fleets are given in the 2004 working group report (ICES WGNSSK (2005) ICES CM 2005/ACFM: 07) and the 1996 working group report (ICES CM 1997/Assess:6). Previous to the 2001 assessment the effort has been standardized by vessel category (to a standard 175 GRT vessel) only using the catch rate proportions between vessel size categories within the actual year. In 2002, a new regression standardization method was introduced (see methodological description below), and the assessment was run both with and without the new standardization method (regression). The differences in results of output SSB, TSB and F between the two assessment runs were small.

With respect to further exploration of the effect of using effort standardization and using a combined Danish and Norwegian commercial fishery tuning fleet in the Norway pout assessment (including data up to 2006) different analyses have been made in relation to this in the benchmark assessment in 2004. This was done to investigate alternative standardization methods and alternative division of the commercial fishery assessment tuning fleet used in the assessment. The results of these analyses were presented to and discussed by the working group in 2004 and presented in the 2004 working group report in section 12 (ICES CM 2005/ACFM:07). Since 2002, the assessments have used output of the regression analyses using time series from 1987(1994)-most recent assessment year, where the regressions have been applied to the Danish and Norwegian commercial fishery. Effort standardization of both the Danish and the Norwegian part of the commercial fishery tuning series is performed by applying standardization factors to reported catch and effort data for the different vessel size categories. The standardization factors are obtained from regression of CPUE indices by vessel size category over years of the Danish commercial fishery tuning fleet. The number of small vessels in the Danish Norway pout fishing fleet has decreased significantly and the relative number of large vessels has increased in the more recent years. Furthermore, there were found no trends in CPUE between vessel categories over time. For these reasons the CPUE indices used in the regression has been obtained from pooled catch and effort data over the years 1994-present assessment year by vessel category in order to obtain and include estimates for all vessel categories also for the latest years where no observations exists for the smallest vessels groups.

The conclusion of the discussion in the working group of these analysis results was that further analysis and exploration of data is necessary before suggesting an alternative standardization method and alternative division of commercial fishery tuning fleets (potentially) to be used in the assessment. This should be done in a coming benchmark assessment of the stock. Among other it should be further investigated whether it is possible to split the Danish and Norwegian commercial tuning fleet, and also effects of excluding the commercial tuning fleets from the assessment should be further exploited. See also comments to future benchmarking further below.

Parameter estimates from regressions of ln(CPUE) versus ln(average GRT) by period together with estimates of standardized CPUE to the group of Danish 175 GRT industrial fishery trawlers is shown for the period 1994-2006 in this quality control handbook below.

The regression model used in effort standardisation is the following:

Regression models: $CPUE=b*GRT^{a} \Rightarrow \ln(CPUE)=\ln(b)+a*\ln((GRT-50))$

Parameter estimates from regressions of ln(CPUE) versus ln(average GRT) by period together with estimates of standardized CPUE to the group of Danish 175 GRT industrial fishery trawlers is used to standardize effort in the commercial fishery tuning fleet used in the Norway pout assessment. Parameter estimates for the period 1994-2006 is the following:

Year	Slope	Intercept	R-Square	CPUE(175 tonnes)
1994-2006	0.18	14.05	0.77	32.76

Norwegian effort data

In 1997, Norwegian effort data were revised as described in sections 13.1.3.1 and 1.3.2 of the 1997 working group report (ICES CM 1998/Assess:7). Furthermore, in the 2000 assessment Norwegian average GRT and Effort data for 1998-99 were corrected because data from ICES area IIa were included for these years in the 1998-99 assessments. Observed average GRT and effort for the Norwegian commercial fleets are given in the input data to the yearly performed assessment. This information has been put together in the report of the ICES WGNSSK meeting in 2004 (ICES WGNSSK (2005), ICES CM 2005/ACFM:07). No Norwegian effort data exist for the commercial fishery tuning fleet in 2005, the first part of 2006, and in 2007 due to closure of the fishery. Norwegian effort data for the directed Norway pout fishery in 2008 has not been prepared because the fishery has been on low level, and data for 2010-2013 has not been prepared because of introduction of selective grids in the Norwegian fishery since 2010. See also comments on benchmarking further below.

Danish effort data

In each yearly assessment the input data as CPUE data by vessel size category and year for the Danish commercial fishery in area IVa is given. This is based on fishing trips where total catch included at least 70 % Norway pout and blue whiting per trip, and where Norway pout was reported as main species in catch in the logbook per fishing day and fishing trip. There has been a relative reduction in the number and effort of small vessels and an increase for the larger vessels in the fleet in the latest years. Furthermore, it appears clearly that there is big difference in CPUE (as an indicator of fishing power) between different vessel size categories (BRT). Accordingly, standardization of effort is necessary when using a combined commercial fishery tuning fleet in the assessment including several vessel categories. Minor revisions (up-dating) of the Danish effort and catch data used in the effort standardization and as input to the tuning fleets have been made for the 2001 assessment. No Danish effort data exist for the commercial fishery tuning fleet in 2005, the first part of 2006, and in 2007 as well as the first part of 2011 and 2012 due to closure of the fishery.

Exploration of methods for effort standardization

With respect to further exploration of the effect of using effort standardization and using a combined Danish and Norwegian commercial fishery tuning fleet in the Norway pout assessment (including data up until 2006) different analyses have been made in relation to the benchmark assessment in 2004. This was done to investigate alternative standardization methods and alternative division of the commercial fishery assessment tuning fleet used in the assessment. The results of these analyses were presented to the working group and were discussed here in 2004 (ICES CM 2005/ACFM:07).

Analysis of variance (GLM-analyses) of catch, effort and log transformed CPUE data on trip basis for the Danish commercial fishery for Norway pout during the period 1986 to 2004 showed statistical significant differences in catch rates between different GT-groups, years, quarters of years (seasons), and fishing areas, as well as statistical significant first order interaction effects between all of these variables. The detailed patterns in this variation are not clear and straight forward to conclude on.

It has so far not been possible to obtain disaggregated effort and catch data by area and vessel size (GT-group) from the Norwegian Norway pout fishery to perform similar analyses for the Norwegian fishery.

Also, it is not possible to regenerate the historical time series (before 1996) of catch numbers at age in the commercial fishery tuning fleet by nation which is only available for the combined Danish and Norwegian commercial tuning fleet. The reason for this is partly that there is no documentation of historical allocation of biological samples (mean weight at age data) to catch data (catch in weight) in the tuning fleet in order to calculate catch number at age for the period previous to 1996 for both nations, and partly because it seems impossible to obtain historical biological data for Norway pout (previous to 1996) from Norway. Alternative division of the commercial fishery tuning fleet would, thus, need new allocation of biological data to catch data for both the Danish and Norwegian fleet, and result in a significantly shorter Norwegian commercial fishery tuning fleet time series, and a historically revised Danish commercial fishery tuning fleet with new allocation of biological data to catch data. Revision of the tuning fleet would, furthermore, need analyses of possible variation in biological mean weight at age data to be applied to different fleets, as well as of the background for and effect of this possible variation.

Standardized effort data

The resulting combined and standardized Danish and Norwegian effort for the commercial fishery used in the assessment is presented in the input data to the yearly performed assessment, as well as the combined CPUE indices by age and quarter for the commercial fishery tuning fleet (Table 6 below).

The seasonal variation in effort data is one reason for performing a seasonal VPA.

Revision of assessment tuning fleets (survey CPUE data and commercial fishery CPUE data) in the 2004 benchmark assessment (commercial fishery tuning fleet):

Revision of the Norway pout assessment tuning fleets was performed during the 2004 benchmark assessment. The background for this, the results, and the conclusions from the analyses in relation to this are described here in the stock quality handbook as well as in the benchmark assessment in the working group report from 2004. Revision of the Norway pout assessment tuning fleets during benchmark assessment have been based partly on cohorte analyses and analyses of correlations within and between the different tuning fleet indices by age group, as well as on the results from a row of exploratory assessment runs described under section 12.3 of the 2004 benchmark assessment (ICES WGNSSK (2005)) which analyses the performance of the different tuning fleets in the assessment. The exploratory assessment runs also give indications of possible catchability patterns and trends in the fishery over time within the assessment period. The analyses of the tuning fleet indices are presented in the benchmark assessment 2004 (ICES WGNSSK (2005)) Figures 12.2.3-12.2.8 and Tables 12.2.9-12.2.12.

The current benchmark assessment should evaluate usefulness of using the commercial fishery tuning time series in the assessment from Danish and Norwegian commercial fishery. This should take into consideration influence on cpue and targeting in the Norway pout fishery based on the several fishing closures (several real time management closures) in recent years, introduction of selective devices in recent years being different for Norwegian and Danish fishery, different targeting in Danish and Norwegian Norway pout fisheries (Norway pout, blue whiting), as well as yearly changes in fleet efficiency given changes in vessel sizes targeting Norway pout over time.

Table 7. Overview over the resulting tuning data time series and fleets included and used in the assessment during different time periods (by year and age) in the assessment (From ICES WGNSSK 2015 Report covering the September 2015 Norway pout assessment).

Table 5.3.1 **Norway pout IV & IIIaN (Skagerrak). Tuning fleets and indices used in the final 2004 benchmark assessment as well as in the 2005-2015 assessments compared to the 2003 assessment.**

		2003 ASSESSMENT	2004, 2005, April 2006 ASSESSMENT	Sept. 2006 ASSESSMENT	2007-15 ASSESSMENTS
Recruiting season		3rd quarter	2nd quarter (SXSA)	3rd quarter (SMS); 2nd quarter (SXSA)	3rd quarter (SXSA)
Last season in last year		3rd quarter	2nd quarter (SXSA)	3rd quarter (SMS); 2nd quarter (SXSA)	1st quarter (SXSA)
Plus-group		4+	4+ (SXSA)	None (SMS); 4+ (SXSA)	4+ (SXSA)
FLT01: comm Q1					
	Year range	1982-2003	1982-2004	1982-2004	1982-2004, 2006
	Quarter	1	1	1	1
	Ages	1-3	1-3	1-3	1-3
FLT01: comm Q2			NOT USED	NOT USED	NOT USED
	Year range	1982-2003			
	Quarter	2			
	Ages	1-3			
FLT01: comm Q3					
	Year range	1982-2003	1982-2004	1982-2004	1982-2004, 2006
	Quarter	3	3	3	3
	Ages	0-3	1-3	1-3	1-3
FLT01: comm Q4					
	Year range	1982-2003	1982-2004	1982-2004	1982-2004, 2006
	Quarter	4	4	4	4
	Ages	0-3	0-3	0-2 (SMS); 0-3 (SXSA)	0-3 (SXSA)
FLT02: ibtsq1					
	Year range	1982-2003	1982-2006	1982-2006	1982-2014
	Quarter	1	1	1	1
	Ages	1-3	1-3	1-3	1-3
FLT03: egfs					
	Year range	1982-2003	1992-2005	1992-2005	1992-2013
	Quarter	3	Q3 -> Q2	Q3 -> Q2	Q3
	Ages	0-3	0-1	0-1	0-1
FLT04: sgfs					
	Year range	1982-2003	1998-2006	1998-2006	1998-2013
	Quarter	3	Q3 -> Q2	Q3 -> Q2	Q3
	Ages	0-3	0-1	0-1	0-1
FLT05: ibtsq3		NOT USED			
	Year range		1991-2005	1991-2005	1991-2013
	Quarter		3	3	Q3
	Ages		2-3	2-3	2-3

2. Distribution of the Norway pout stock in relation to the fishery

B.1. DISTRIBUTION OF THE STOCK IN RELATION TO THE FISHERY BASED ON SURVEY DATA AND SURVEY TUNING TIME SERIES USED IN THE ASSESSMENT

Survey tuning time series used in the Norway pout assessment

Trawl survey index time series of abundance of Norway pout by age and quarter are for the assessment period available from the ICES International Bottom Trawl Survey (IBTS Q1 and Q3) and the English Ground-fish Survey (EGFS Q3 being a part of IBTS Q3) and the Scottish Ground-fish Survey (SGFS Q3 being a part of IBTS Q3). An overview of the survey tuning time series included used by year and age in the assessment during different assessment periods is shown in Table 1 below.

The survey trawl survey indices for Norway pout are in form of standard abundance and density indices estimated as the catch per unit of effort (CPUE in number of fish per hour) by age for the international bottom trawl surveys coordinated by ICES and conducted according to ICES standard survey and sampling design (www.ices.dk).

Table 1. Norway pout IV & IIIaN (Skagerrak). Tuning fleets and indices used in the final 2004 benchmark assessment, in the 2005-2015 assessments, as well as in the 2016 assessment, compared to the 2003 assessment. Changes marked with grey.

		2003 ASSESSMENT	2004, 2005, April 2006 ASSESSMENT	Sept. 2006 ASSESSMENT	2007-15 ASSESSMENTS	2016- ASSESSMENTS
Recruiting season		3rd quarter	2nd quarter (SXSA)	3rd quarter (SMS); 2nd quarter (SXSA	2nd quarter (SXSA), autumn assessm.	3rd quarter SESAM
Last season in last year		3rd quarter	2nd quarter (SXSA)	3rd quarter (SMS); 2nd quarter (SXSA	2nd quarter (SXSA), autumn assessm.	3rd quarter SESAM
Plus-group		4+	4+ (SXSA)	None (SMS); 4+ (SXSA)	4+ (SXSA)	4+ (SESAM)
FLT01: comm Q1						
	Year range	1982-2003	1982-2004	1982-2004	1982-2004, 2006	NOT USED
	Quarter	1	1	1	1	
	Ages	1-3	1-3	1-3	1-3	
FLT01: comm Q2			NOT USED	NOT USED	NOT USED	NOT USED
	Year range	1982-2003				
	Quarter	2				
	Ages	1-3				
FLT01: comm Q3						
	Year range	1982-2003	1982-2004	1982-2004	1982-2004, 2006	NOT USED
	Quarter	3	3	3	3	
	Ages	0-3	1-3	1-3	1-3	
FLT01: comm Q4						
	Year range	1982-2003	1982-2004	1982-2004	1982-2004, 2006	NOT USED
	Quarter	4	4	4	4	
	Ages	0-3	0-3	0-2 (SMS); 0-3 (SXSA)	0-3 (SXSA)	
FLT02: ibtsq1						
	Year range	1982-2003	1982-2006	1982-2006	1982-2015	1982-2016
	Quarter	1	1	1	1	1
	Ages	1-3	1-3	1-3	1-3	1-3
FLT03: egfs						
	Year range	1982-2003	1992-2005	1992-2005	1992-2015	1992-2016
	Quarter	3	Q3 -> Q2	Q3 -> Q2	Q3 -> Q2	3
	Ages	0-3	0-1	0-1	0-1	0-1
FLT04: sgfs						
	Year range	1982-2003	1998-2006	1998-2006	1998-2015	1998-2015
	Quarter	3	Q3 -> Q2	Q3 -> Q2	Q3 -> Q2	3
	Ages	0-3	0-1	0-1	0-1	0-1
FLT05: ibtsq3		NOT USED				
	Year range		1991-2005	1991-2005	1991-2014	1991-2015
	Quarter		3	3	Q3	3
	Ages		2-3	2-3	2-3	2-3

1) The IBTS Q1 tuning fleet has remained unchanged compared to previous years assessments and benchmark assessments.

It should be noted that in the 2014 IBTS Q1 survey, less hauls were conducted in the northern part of the North Sea than usual. This did not result in change in the log residual stock numbers, the log inverse catchabilities, and the weighting factors for computing survivors in the assessment for this survey.

2) The SGFS Q3 for age group 0 and 1 for the period 1998 and onwards has been used as tuning fleet in the assessment. The short time series is due to the change in survey design for SGFS.

The SGFS data from 1998 onwards should be used with caution due to new survey design (new vessel from 1998 and new gear and extended survey area from 1999). The 0-group indices from this survey have accordingly not been used in the assessment tuning fleet for this survey previous to the 2004 benchmark assessment. The index for the 0-group from SGFS changed with an order of magnitude in the years after the change in survey design compared to previous years (Table 12.2.8, ICES WGNSSK (2005)).

From 2009 and onwards the SGFS changed its survey area slightly with a few more hauls in the northern North Sea and a few less hauls in the German Bight. This is not evaluated to influence the indices significantly as the indices are based on weighted sub-area averages.

In 3rd quarter 2015 and 2016 test trials were conducted in the international third quarter IBTS with 15 min duration hauls compared to 30 min duration hauls. The new 15 min test hauls have been included in the index calculation for 3rd quarter 2015 and 2016, and will potentially affect the Norway pout indices for the SGFS, the EGFS and the combined IBTS Q3 index. It has been necessary to include the 15 min hauls in the SGFS 2015 and 2016 as extensive areas (of the total SGFS survey area) are only covered with this type of hauls. Analyses of this are on-going and nothing conclusive is available at present concerning potential significant impacts of this on the indices. Preliminary analyses indicate no significant differences in catch rates of Norway pout between the 15 min hauls and the 30 min hauls in the SGFS, however, the variability is very high and there are only very few observations available.

For the September assessments up to and including 2015 the quarter 3 0-group and 1-group survey indices for SGFS is back-shifted to the final season of the assessment in the terminal year, i.e. to quarter 2 of the assessment year in order to include the most recent 0-group estimate in the assessment. From 2016 with use of the SESAM model including quarter 3 information in the terminal assessment year this back shifting is not necessary.

3) The EGFS Q3 for age group 0 and 1 for the period 1992 and onwards has been used as tuning fleet in the assessment. The shorter time series is due to the change in survey design for EGFS. Furthermore, there is a good argument for excluding the age 2-3 of the EGFS as the within survey correlation between the age groups 1-2 and 2-3 is very poor while the within correlation between age groups 0-1 is good.

The EGFS data from previous to 1992 should be used with caution as the survey design shifted in 1992. This change in survey design has until 2004 been accounted for by simply multiplying all indices with a factor 3.5 for all age groups in the years previous to 1992 in order to standardize it to the later indices. The EGFS survey indices for Norway pout has been revised in the 2004 assessment compared to the previous years assessment for the 1996, 2001, 2002, and 2003 indices. In previous years assessments (before 2004) the full EGFS survey time series for all age groups have been included as an assessment tuning fleet.

In September 2015, the EGFS survey indices were revised as to incorporate the relevant primes within the Norway pout area following the IBTS Manual (2015), i.e. in the selection of the prime stations to be included in the Norway pout index calculation. The revision is described in detail in an ICES working document to ICES WGNSSK 2015 (Silva, 2015). This has changed the EGFS indices for Norway pout for all years and ages since 1992. Especially, the indices for the 0-group have changed significantly without any obvious trends over time. However, the perception of the dynamics in the stocks (e.g. strong year classes as 0-group and also as older ages in the cohorts) seems not to have changed in relative terms. Consequently, there is consistency in this to the previous EGFS indices and in relation to the other survey indices also for Norway pout. The log inverse catchabilities in the September 2015 SXSA assessment have increased slightly for the EGFS in 2015 compared to previous years assessments, while the weighting factors for computing survivors in the September 2015 SXSA assessment were quite similar to those from previous years SXSA assessments. Also, this seems not to have affected the log residual stock numbers.

In 3rd quarter 2015 and 2016 test trials were conducted in the international third quarter IBTS with 15 min duration hauls compared to 30 min duration hauls. The new 15 min test hauls have been included in the index calculation for 3rd quarter 2015 and 2016, and will potentially affect the Norway pout indices for the SGFS, the EGFS and the combined IBTS Q3 index. Only one 15 min test haul was included in the EGFS 2015. Analyses of this are on-going and nothing conclusive is available at present concerning potential significant impacts of this on the indices.

For the September assessments up to and including 2015 the quarter 3 0-group and 1-group survey indices for EGFS is back-shifted to the final season of the assessment in the terminal year, i.e. to quarter 2 of the assessment year in order to include the most recent 0-group estimate in the assessment. From 2016 with use of the SESAM model including quarter 3 information in the terminal assessment year this back shifting is not necessary.

4) Time series for the combined IBTS Q3 survey are only available from 1991 and onwards. The IBTS Q3 for the period 1991- onwards has been included in the assessment. This survey has a broader coverage of the Norway pout distribution area compared to the EGFS and SGFS isolated. The 3rd quarter IBTS and the EFGS and SGFS are not independent of each other as the two latter is a part of the first. Accordingly, the below changes have been made for the survey tuning index series in the 2004 benchmark assessment.

As the combined IBTS Q3 survey index is not available for the most recent year (terminal assessment year) to be used in the September seasonal assessment it has been chosen to exclude the 0- and 1-group indices from the IBTS Q3 in order to allow inclusion of the 0- and 1-group indices from the SGFS and EGFS which are available for the most recent year in the September assessment. (Not relevant in relation to spring assessments conducted up to 2015). Accordingly, the IBTS Q3 tuning fleet for age 2 and age 3 has been included in the assessment as a new tuning fleet. As the SXSA assessment model used up to and including 2015 demands at least two age groups in order to run which is one reason for including both age 0 and age 1 under the EGFS and SGFS tuning fleets and not including age 1 in the IBTS Q3 tuning fleet.

In 3rd quarter 2015 and 2016 test trials were conducted in the international third quarter IBTS with 15 min duration hauls compared to 30 min duration hauls. The new 15 min test hauls have been included in the index calculation for 3rd quarter 2015 and 2016, and will potentially affect the Norway pout indices for the SGFS, the EGFS and the combined IBTS Q3 index. Analyses of this are on-going and nothing conclusive is available at present concerning potential significant impacts of this on the indices.

Revision of assessment tuning fleets (survey CPUE data and commercial fishery CPUE data) in the 2004 benchmark assessment:

Revision of the Norway pout assessment tuning fleets was performed during the 2004 benchmark assessment. The background for this, the results, and the conclusions from the analyses in relation to this are described in the Stock Annex (stock quality handbook) as well as in the benchmark assessment in the working group report from 2004.

Revision of the Norway pout assessment tuning fleets during benchmark assessment have been based partly on cohort analyses and analyses of correlations within and between the different tuning fleet indices by age group, as well as on the results from a row of exploratory assessment runs described under section 12.3 of the 2004 benchmark assessment (ICES WGNSSK (2005)) which analyses the performance of the different tuning fleets in the assessment. The exploratory assessment runs also give indications of possible catchability patterns and trends in the fishery over time within the assessment period. The analyses of the tuning fleet indices are presented in the benchmark assessment 2004 (ICES WGNSSK (2005) Figures 12.2.3-12.2.8 and Tables 12.2.9-12.2.12).

Stock distribution according to IBTS survey data

The distribution of the Norway pout stock in the North Sea and Skagerrak-Kattegat is shown as catch per unit of effort (CPUE in number of fish per haul) by age and for all age groups combined in the ICES International Bottom Trawl Surveys (ICES IBTS) in 1st and 3rd quarter of the year for a 30 year period from 1985 to 2016. The data originates from downloads/extracts from the ICES DATRAS database in August 2016.

The distribution of the Norway pout stock as observed in the Quarter 1 North Sea IBTS surveys by year, (quarter), and ICES rectangle for the period 1985-2016 for age groups 1-6 Norway pout aggregated is shown in **Figure 22**. The distribution of stock density patterns are shown on the maps as survey catch per unit of effort (CPUE), i.e. catch rates in number of individuals per trawl hour (no of fish caught). The data used for the calculations are CPUE per age group per survey trawl haul as extracted and downloaded from the ICES DATRAS database. The mean CPUE as number per trawl hour per age group (or summed over age groups) by survey (i.e. by year and quarter) is calculated for each ICES rectangle as the mean number per hour of all hauls performed in each rectangle. The mean CPUE per rectangle are either calculated as averages per year or as averages over several years. The same is shown in **Figure 23** but for the 3rd quarter in the Quarter 3 IBTS survey for the period 1991-2015 and also including the age group 0 which is observed representatively in the third quarter IBTS survey as well. In general, the main abundance consists of 1- and 2-group fish in the surveys because of high natural mortality and gear selectivity (see also Nielsen 2016 – Working Document to WKPOUT 2016) which are also the main age groups caught in the commercial fishery. There is only very limited fishery on 0-group (very small catches).

In the previous sections of the present paper the distribution of the commercial Norway pout fishery has not been shown on age disaggregated basis, but aggregated over ages. When compared to the survey based distribution patterns of the stock, also aggregated over ages, then it appears that the fishery in general is mainly concentrated in the northern North Sea where also the highest densities and abundances of Norway pout occur for all years and quarters during the investigated 30 year period. The distribution by age group of Norway pout is given in Nielsen (2016 - Working Document to WKPOUT) where it is investigated whether the stock has changed its distribution over time for different life stages and seasonal patterns herein.

The IBTS mean CPUE (numbers per hour) by quarter as an average for the full period 1991-2004 is shown in **Figure 24** where the boundary between the EU and the Norwegian EEZ are included on the map as well.

Finally, the positions fished at the International Bottom Trawl Survey (IBTS) first quarter and the mean CPUE (numbers) of Norway pout by rectangle for the full period 1981–1999 is shown in **Figure 25**. The standard area used to calculate abundance indices and the 200 m depth contour is also shown.

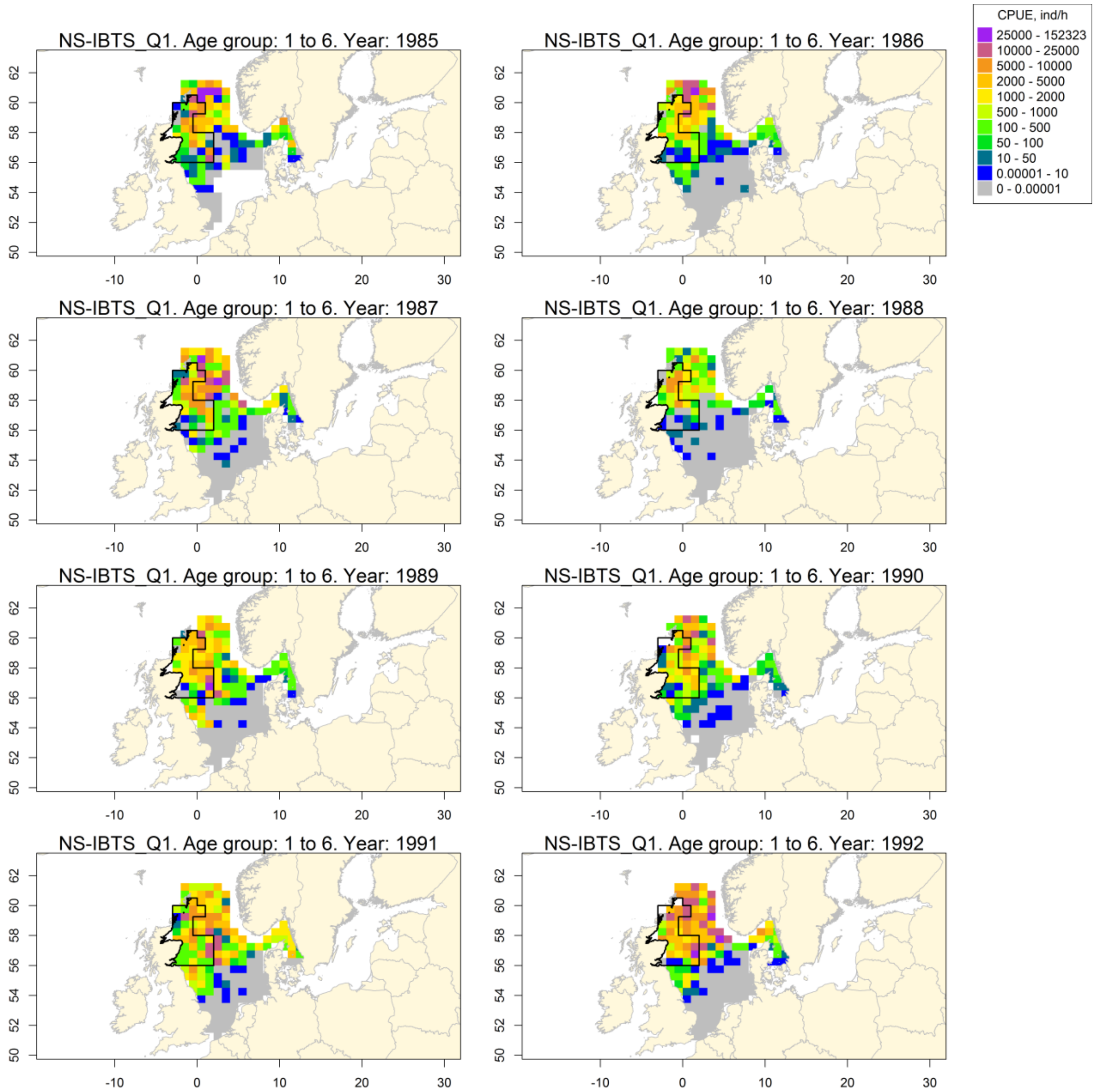


Figure 22. Catch per unit of effort (No/h) of Norway pout by year, (quarter), age, and ICES rectangles for the IBTS Quarter 1 survey in the period 1985-2016. The “Norway pout box” is shown on the maps.

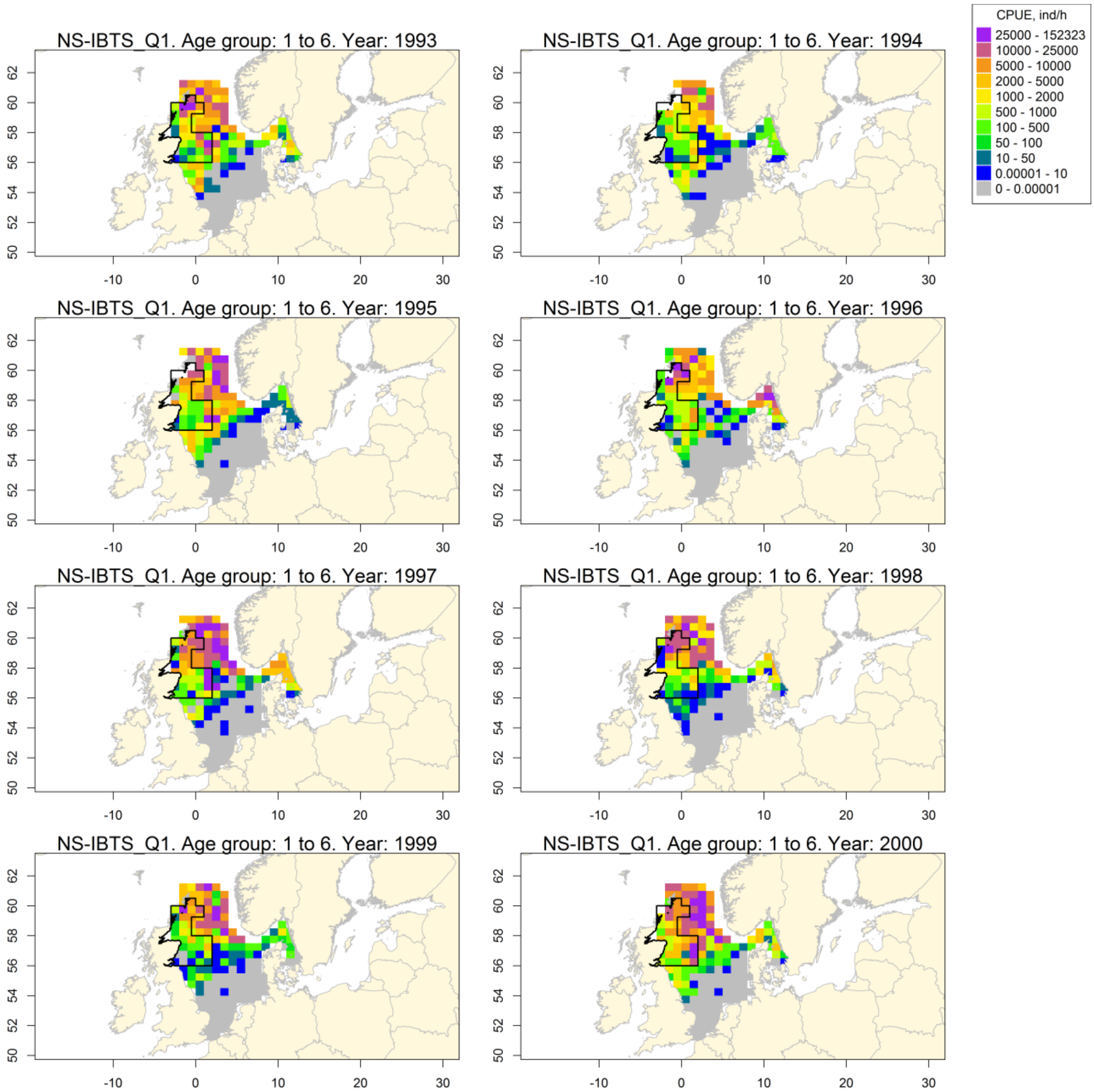


Figure 22. (Continued).

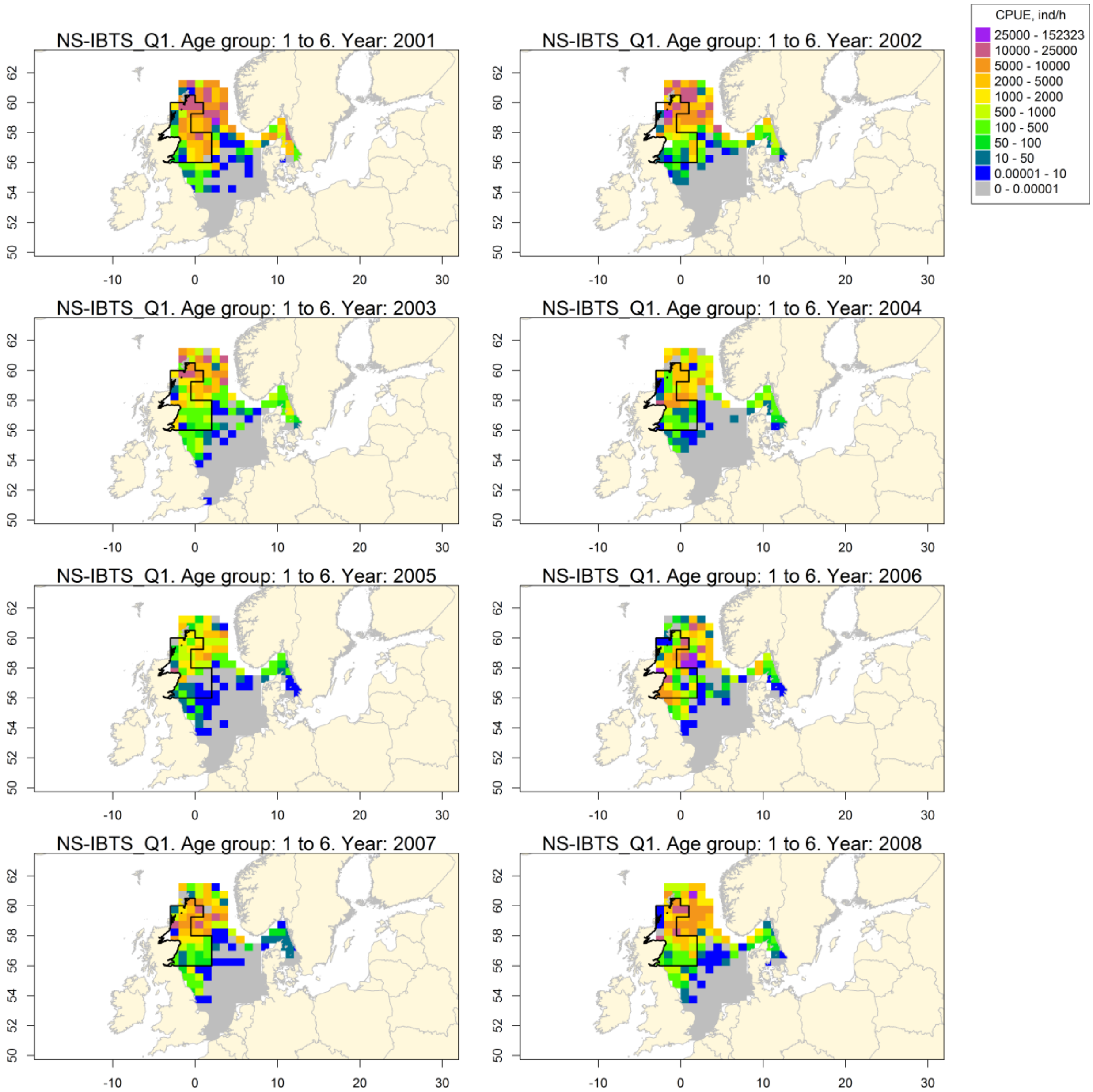


Figure 22. (Continued).

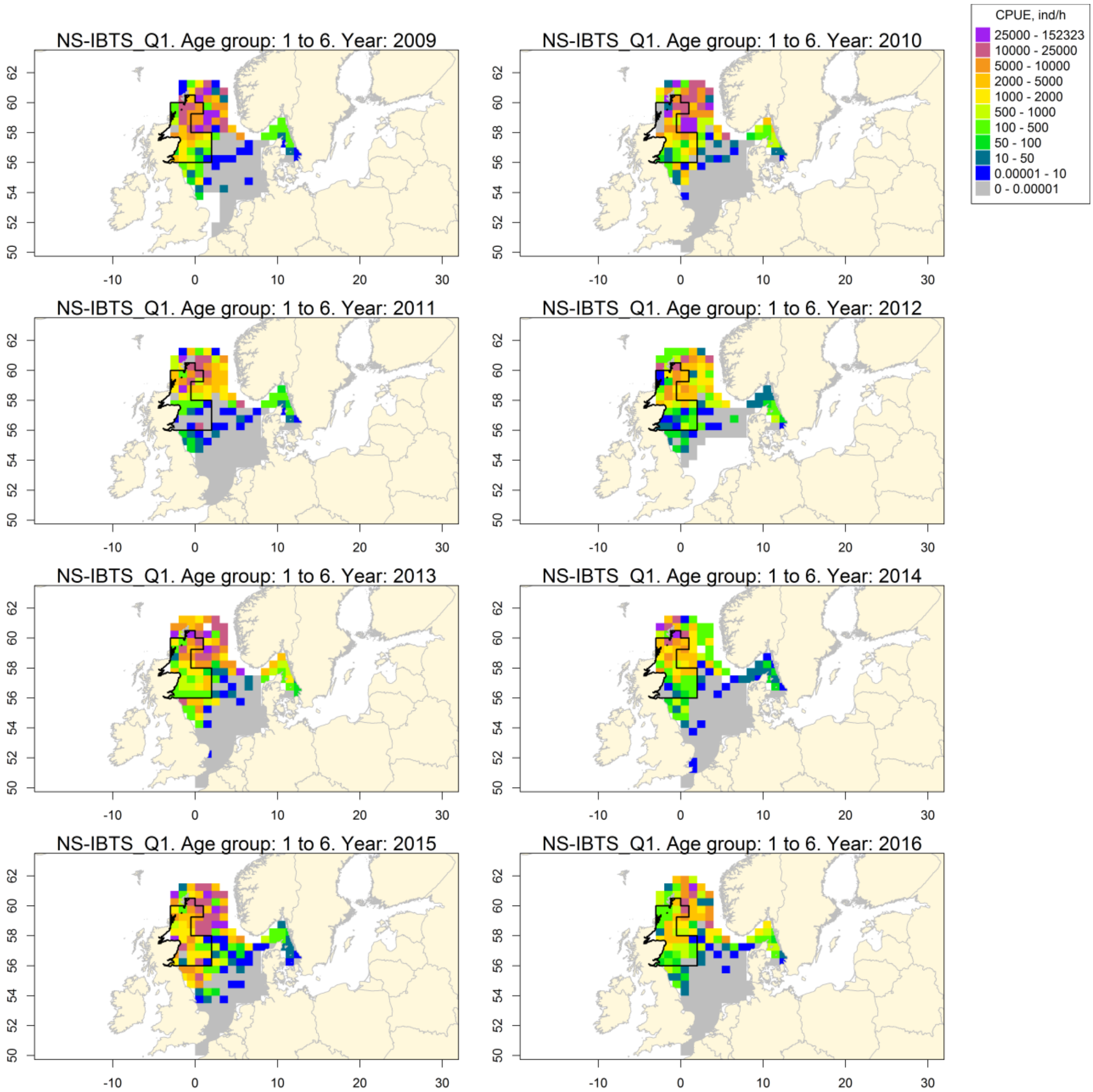


Figure 22. (Continued).

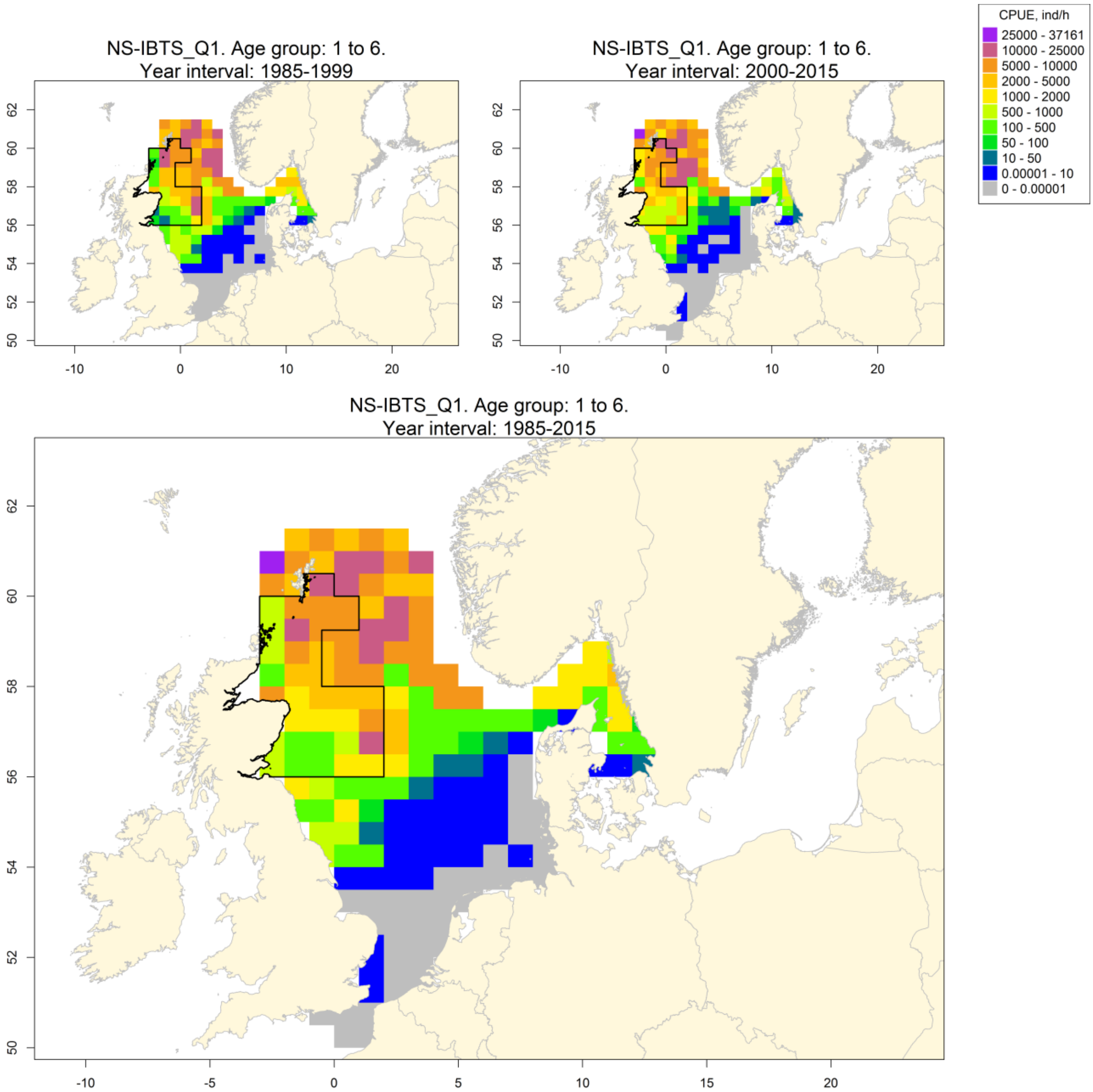


Figure 22. (Continued).

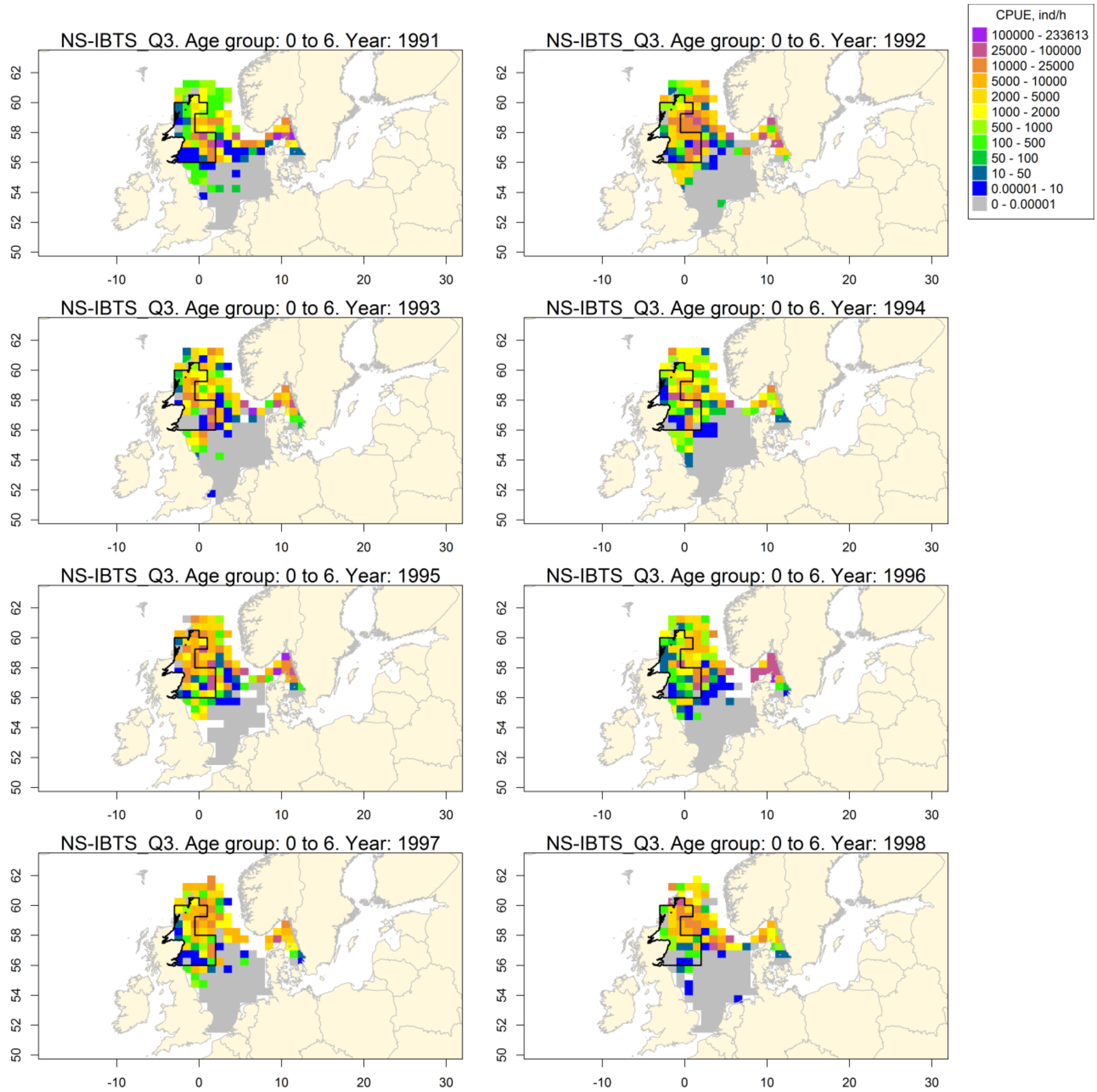


Figure 23. Catch per unit of effort (No/h) of Norway pout by year, (quarter), age, and ICES rectangles for the IBTS Quarter 3 survey in the period 1991-2015. The “Norway pout box” is shown on the maps.

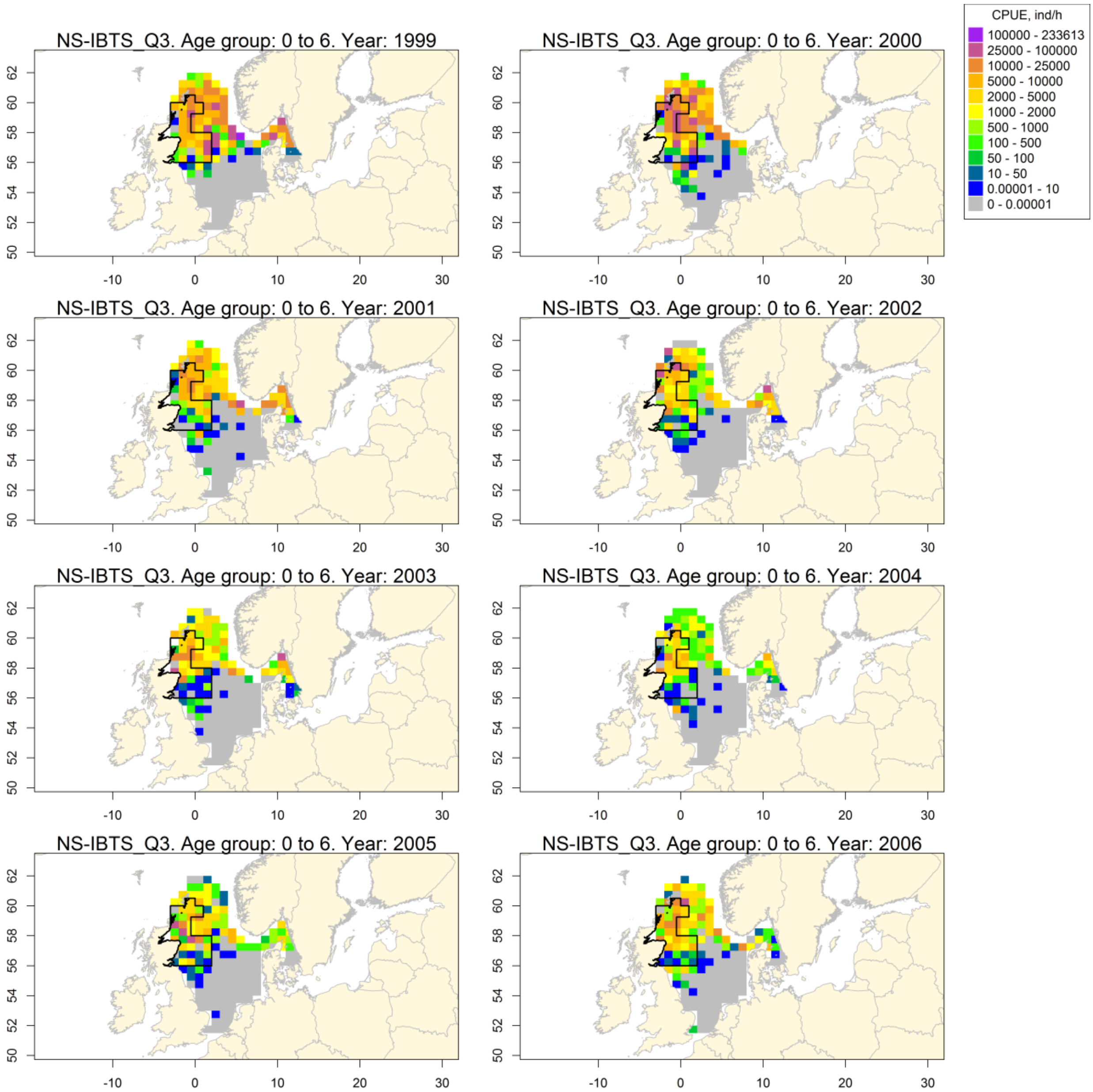


Figure 23. (Continued).

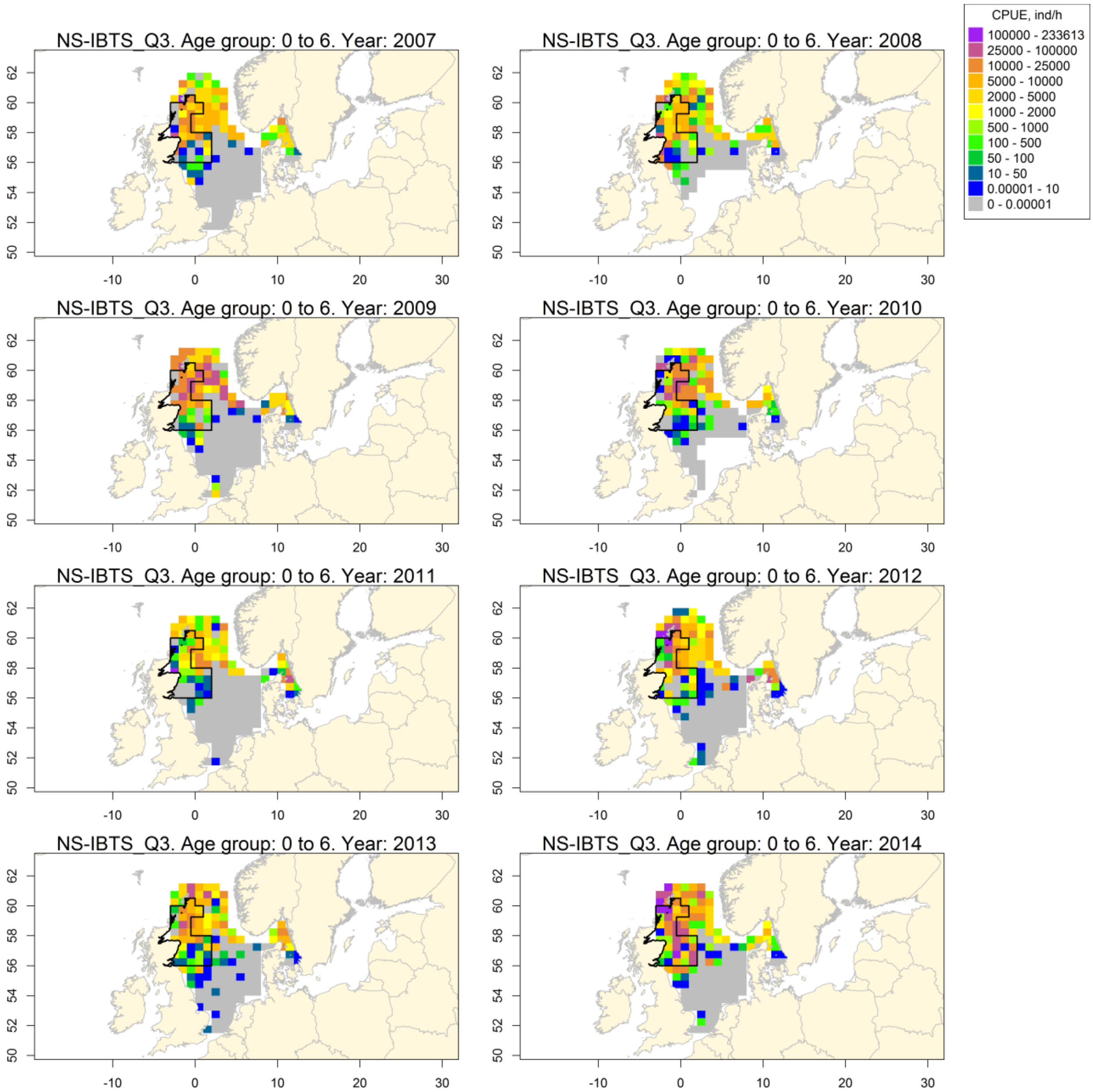


Figure 23. (Continued).

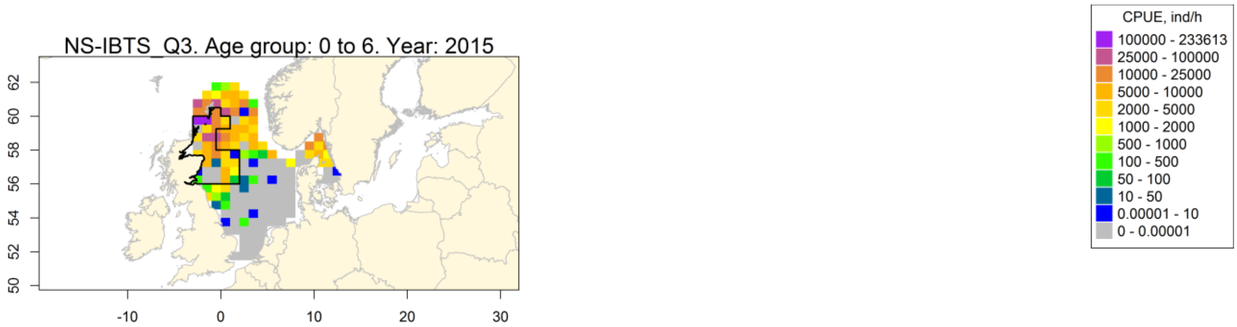


Figure 23. (Continued).

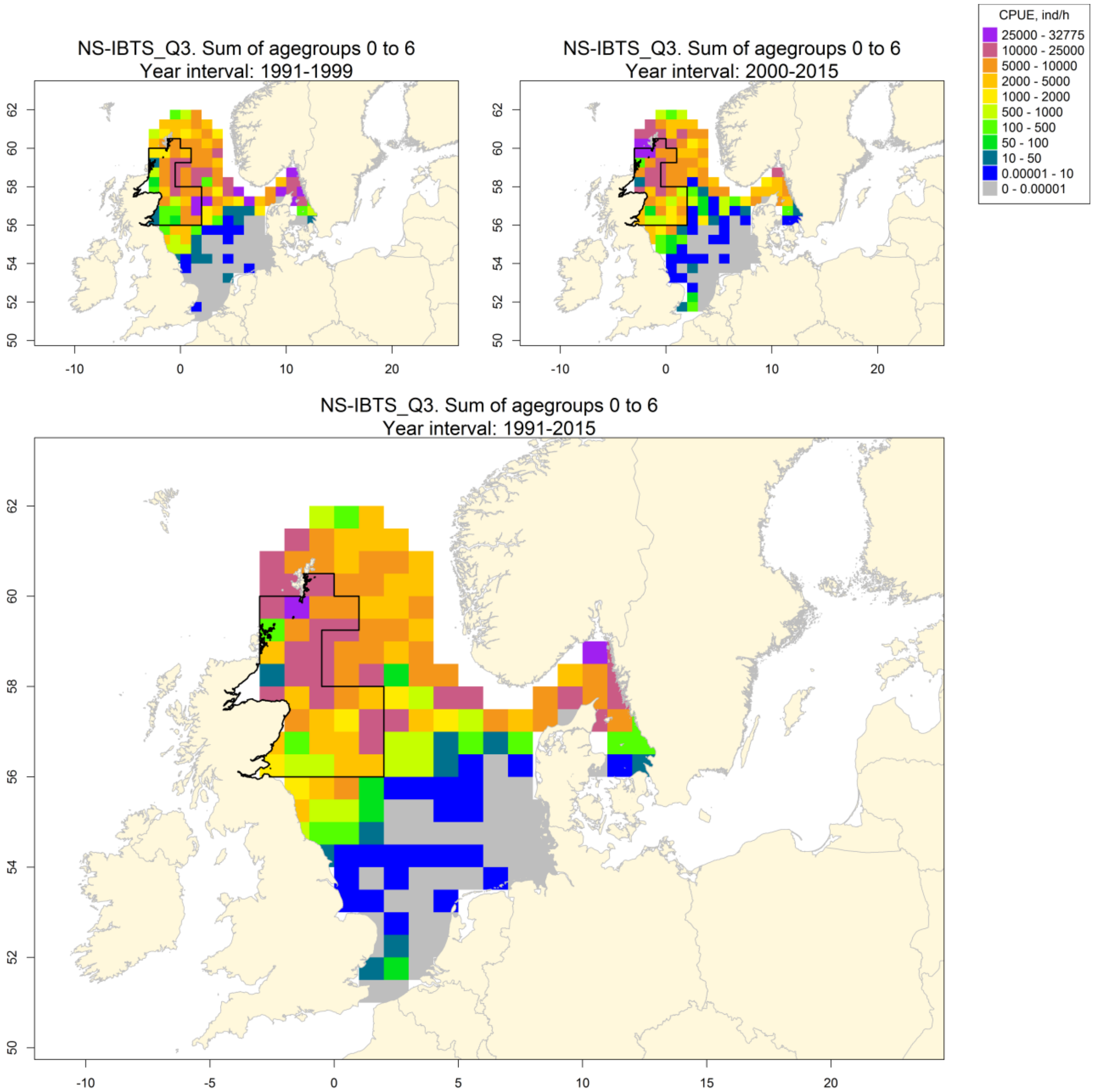


Figure 23. (Continued).

IBTS Quarter 1

IBTS Quarter 3

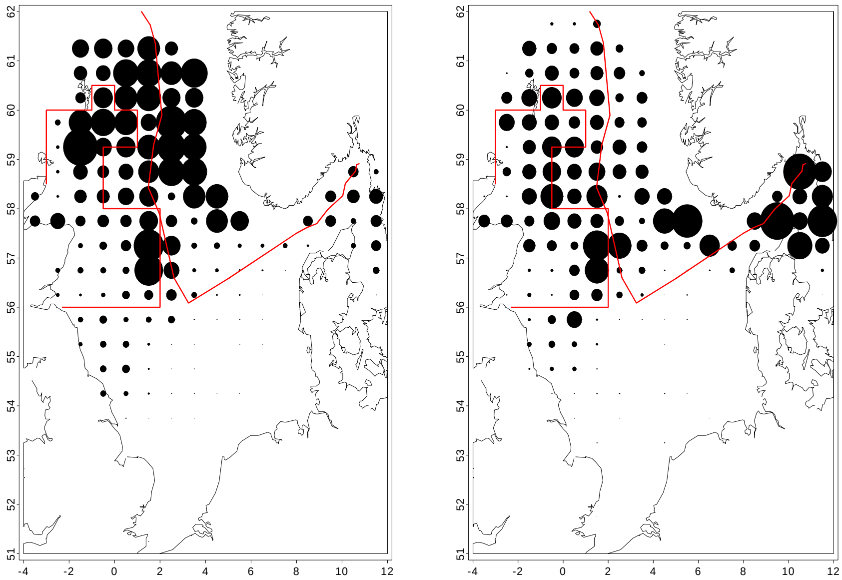


Figure 24. IBTS mean CPUE (numbers per hour) by quarter during the period 1991-2004. The area of the circles is proportional to CPUE. The IBTS surveys do only cover areas within the 200 m depth zone. The “Norway pout box” and the boundary between the EU and the Norwegian EEZ are shown on the map. The maps are scaled individually. (From EU 2007).

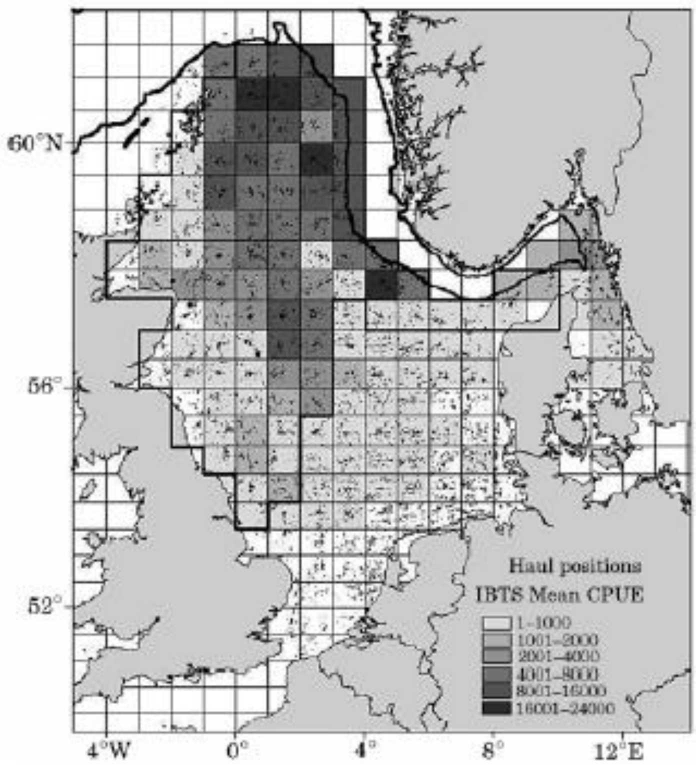


Figure 25. Positions fished at the International Bottom Trawl Survey (IBTS) first quarter and mean CPUE (numbers) of Norway pout by rectangle, 1981–1999. The standard area used to calculate abundance indices and the 200 m depth contour is also shown [from Sparholt *et al.*, 2002b].

3. Relevant fishery regulations for the Norway pout fishery

C.1 Overview of some recent management measures and regulations relevant for the Norway pout fishery and stock:

The Norway pout fishery is regulated by Total Allowable Catch (TAC), i.e. catch quotas, effort ceilings, as well as a row of technical measures and by-catch regulations. In order to protect other species (cod, haddock, saithe, whiting, and herring as well as mackerel, monkfish, squids, flatfish, gurnards, *Nephrops*) there is a row of technical management measures in force for the small meshed fishery in the North Sea such as area closures, minimum mesh size, selective grids/panels in the small meshed gears, as well as by-catch regulations (by-catch quotas of herring and maximum by-catch percentages for gadoids and herring) and minimum landing size regulations. An overview of relevant regulations for the Norway pout fishery and stock is given below.

TAC and catch quota regulations:
According to the yearly EU TAC-Quota Regulations based on the yearly Agreed Records between EU and Norway (e.g. TAC and Quota Regulations (2341/2002, 2287/2003, 27/2005) there is set an annual TAC for Norway pout. An overview of the management advice forming basis for the setting of the TAC is shown in **Table 8** and the actual quotas are shown in **Table 9**.

Table 8. The management advice that forms basis for setting of the TAC for Norway pout in Subarea IV and Division IIIa, i.e. the basis of the assessment.

ICES stock data category	1 (ICES, 2015b).
Assessment type	Age-based analytical (seasonal XSA, SXSA).
Input data	Commercial catches (quarterly catches; ages and mean weight-at-age from catch sampling of mainly Danish and Norwegian fishery), four survey indices (IBTS Q1&3, EngGFS-IBTS-Q3, ScoGFS-IBTS-Q3), three commercial indices (CFQ1,Q3,Q4, until 2006). Annual maturity data from commercial catch sampling, natural mortality from survey indices (IBTS Q1&3).
Discards and bycatch	Discards and bycatch of Norway pout considered negligible; not included in the assessment.
Indicators	None.
Other information	None.
Working group	Working Group on the Assessment of Demersal Stocks in the North Sea and Skagerrak (WGNSSK).

Table 9. Norway pout in Subarea IV and Division IIIa. History of ICES advice, the agreed TAC (quotas), official catches, and ICES estimates of catch. All weights are in thousand tonnes.

Year	ICES advice	Pred. catch corresp. to advice	TAC Norway	TAC EU*	Official catch	ICES catch
1987	No advice	-	No TAC	200	215	147
1988	No advice	-	No TAC	200	187	102
1989	No advice	-	No TAC	200	276	167
1990	No advice	-	No TAC	200	212	140
1991	No advice	-	No TAC	200	223	155
1992	No advice	-	No TAC	200	335	255

1993	No advice	-	No TAC	220	241	176
1994	No advice	-	No TAC	220	214	176
1995	Can sustain current F	-	No TAC	180	289	181
1996	Can sustain current F; take bycatches into consid.	-	No TAC	220	197	122
1997	Can sustain current F; take bycatches into consid.	-	No TAC	220	155	133
1998	Can sustain current F; take bycatches into consid.	-	No TAC	220	72	62
1999	Can sustain current F; take bycatches into consid.	-	No TAC	220	93	85
2000	Can sustain current F; take bycatches into consid.	-	No TAC	220	182	175
2001	Can sustain current F; take bycatches into consid.	-	No TAC	211.2	63	57
2002	Can sustain current F; take bycatches into consid.	-	No TAC	198	93	74
2003	Can sustain current F; take bycatches into consid.	-	No TAC	198	24	21
2004	The stock is in risk of decreasing below B_{lim}	-	No TAC	198	16	14
2005	Fishery should be closed		Only bycatch	5	1	2
2006	Fishery closed until 4th August where a TAC of 95 000 t was set.		No TAC	95	54	47
2007	Fishery closed because SSB < B_{pa} in 2008.	0	Only bycatch	5	6	6
2008	F = 0.35 or 50 000 t for first half of 2008	< 50 in 1st 6 months		41		
In-year **	Maintain SSB > B_{pa}	< 148	80	114.6	39	36
2009	Reduce F to increase SSB > B_{pa}	< 35		28.3		
In-year **	Maintain SSB > B_{pa}	< 157	128	116.3	55	56
2010	Maintain SSB > B_{pa}	< 307	86	76		
In-year **	Maintain SSB > MSY $B_{escapement}$	< 434		163	137	126
2011	No directed fisheries	0				
In-year **	Maintain SSB > MSY $B_{escapement}$	< 6	3	4.5	7	7
2012	No fisheries	0		0		
In-year **	No fisheries	0			30	27
In-year ***	Maintain SSB > MSY $B_{escapement}$	< 101	25	70.7		
2013	Maintain SSB > MSY $B_{escapement}$	< 458, $C_{'12}$=0 < 393, $C_{'12}$ =101	157	165.7	82	82
In-year **	Maintain SSB > MSY $B_{escapement}$	< 457				
2014	Maintain SSB > MSY $B_{escapement}$	< 216	108	128.3		44
In-year **	Maintain SSB > MSY $B_{escapement}$	< 108	123			
2015	Precautionary considerations (F = 0.6)	< 326	163	150		
2016	MSY approach (escapement biomass with F_{cap})	< 390				

* Divisions IIIa(EU) and IIIa, and Subarea IV(EU).
** For Norway pout preliminary advice was given in autumn, while the in-year advice was given in June on the basis of the first surveys and catches in the TAC year.
*** Update of in-year advice in October 2012.

For the Danish demersal fishery there is on national basis introduced individual transferable catch quotas in form of a vessel quota shares which is also practiced in the Danish Norway pout fishery from 2007 onwards.

Effort Regulation and Effort Ceilings

Effort limits in terms of Days-at-Sea: Since 2003, the EU Community has limited the number of days that a fishing vessel can be out of port and fishing in the North Sea and adjacent areas. This is implemented through annexes to the TAC and Quota Regulations (e.g. 2341/2002, 2287/2003, 27/2005). Days at sea may be transferred between vessels with an adjustment for differences in engine power between the vessels. Additional days have been allocated to some member states in respect of decommissioning taking place since 2001.In **Table 10** the effort ceilings for the small meshed Norway pout and sandeel fishery in the North Sea is shown for the years 2003 to 2005.

Table 10. The baseline days-at-sea allocations per month (i.e. before additions to take account of decommissioning) were as follows:

Gear type	**Otter trawl, 100mm (90mm in IIIa) or over**	**Beam trawls, 80mm or over**	**Static demersal nets**	**Demersal longlines**	**Otter trawls 70-99mm (70-89mm in Skagerrak)**	**Trawl fishery 16-31mm**
Typical target species	Cod, haddock, whiting	Plaice and sole	Cod, turbot	Cod	Nephrops	Norway pout, sandeel
2003	9	15	16	19	25	23
2004	10	14	14	17	22	20
2005	10 *	13	13	16	21	19

(*) - including one additional day allowable where administrative sanctions are in place.

As a result of the cod plan (R (EC) No 1342/2008) provisions, in particular with regard to Article 13, as well as in relation to the effort regime in context of Annex IIA to Council Regulation (EC) No 57/2011 there has been maintained effort regulation up until (and including) 2016 for regulated gears in the North Sea including the also TR3 gears which small meshed trawls with cod end mesh sizes of 16-31 mm belongs to. The effort ceilings are set in the yearly EU TAC and Quota Regulations according to the cod management plan for the TR3 fleet including the small meshed fisheries for reduction purposes targeting Norway pout.

Licenses

For Norwegian vessels there is practiced a licensing scheme for vessels fishing with small mesh trawls. This has been a part of a capacity reduction scheme for vessels fishing with small mesh trawl. Accordingly, a small mesh trawl license is required to use a smaller mesh size than 16 mm in the directed fishery for sandeel in the season 15 April – 23 June. The same licence is required in order to participate in the mixed industrial fishery for blue whiting and Norway pout. The number of vessels holding such a license has been reduced substantially the latter years as a result of the capacity reduction scheme put in place in 2002. The potential number of participating vessel was about 75 vessels in 2001. By May 2005 the number of potential participants has been reduced to about 50. In 2004 38 vessels participated in the sandeel fishery. The number of participating vessels in 2005 was 22 as of 24 May 2005.

By-catch regulations:

From 1996 onwards, the by-catch quotas for herring in the small meshed fishery for reduction purposes in respectively the North Sea and IIIa (Skagerrak-Kattegat) was introduced in the yearly EU TAC-Quota Regulations based on the yearly Agreed Records between EU and Norway. This was introduced as a by-catch ceiling which from 1996 onwards resulted in setting an actual yearly by-catch quota of herring. These by-catch quotas were introduced in 1996 because of very high fishing pressure on the North Sea herring stock in this period. The development in the by-catch quotas of herring in the North Sea are shown in **Table 11**.

Table 11. By-catch quotas of herring in 1000 tons for the small meshed fishery for reduction purposes.

Year	By-catch ceiling
Before 1996	0
1996	44
1997	24
1998	22
1999	30
2000	36
2001	36
2002	36
2003	52
2004	38
2005	50
2006	43
2007	32
2008	19
2009	16
2010	14
2011	16
2012	18
2013	14
2014	13
2015	16
2016	13

In July 1996, the herring by-catch rules were tightened up in the EU Member States. Denmark implemented a 10% by-catch limit. In 1999, the (EC) No 1434/98 specifying conditions under which herring may be landed for industrial purposes other than direct human consumption was implemented. Though, Denmark maintained the 10% limit. This national limit was year later adjusted to the EU rules. The EU rules specified 20% herring by-catch in the North Sea (ICES Div. IV) and 10% bycatch in Skagerrak-Kattegat (ICES Div. IIIa). When by-catch ceilings was changed to by-catch quotas in 2013, the by-catch rules were repealed and instead the target species rules according to the technical measures /(EC) No 950/98 was used to limit the by-catches.

In 2015, the landing obligation in EU industrial fisheries was implemented (see below) and the (EC) No 1434/98 was repealed (see below).

From 1998 onwards, target species and by-catch regulations were introduced in the Danish Norway pout fishery through the establishment of the agreed EU Council and EU-Norway Bilateral Regulation of Fisheries by-catch regulations in the Norway pout fishery (e.g. EU Regulation No 850/98 (EU 1998)). Here certain target species minimum percentages were introduced according to the mesh size and mesh type regulations included as well. The by-catch regulations for small meshed fishery (16-31mm in mesh size) in the North Sea stipulated here is that catch retained on board must consist of i) at least 90% of any mixture of two or more target species, or ii) at least 60% of any one of the target species, and no more than 5% of any mixture of cod, haddock, saithe, and no more than 15% of any mixture of certain other by-catch species. These maximum percentages of by-catch species has been in force until 2015 with introduction of the landing obligation regulations (see below).

According to the Appendix (Bilag) 6 Note (Meddelelse) from October 2012 from the Danish Ministry of Food, Agriculture and Fisheries, according to the general rules set in the Ministry Regulation (Bekendtgoerelse) No. 1222 of 16 December 2011 § 2, it is from 15th October 2012 obligatory for all Danish vessels participating in the targeted Norway pout fishery in the North Sea and Skagerrak-Kattegat to use a 35 mm grid in the small meshed trawl gears used in the fishery (typically with cod-end mesh sizes 16-31 mm). The grid needs to be in accordance with the following technical specifications: Solid grid in steel, plastic, glass fibre or nylon with minimum 35 mm bar width, and the grid has to be mounted in a net section in front of the cod-end where it covers the full cross area of the section and with an opening which allows escapement of fish which cannot pass the grid.

In the Commission Delegated Regulation EU No 1395/2014 of 20 October 2014 establishing a discard plan for certain small pelagic fisheries and fisheries for reduction purposes in the North Sea (http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=uriserv:OJ.L_.2014.370.01.0035.01.ENG). According to this Landing Obligation Regulation implemented from 1st January 2015 the percentage catch composition regulations in the Norway pout fishery were omitted. In the small meshed fishery for reduction purposes targeting industrial or small pelagic species it is not allowed to release or discard catches. All catches – disregarding catch composition – shall be taken on board and be landed. Previous regulations for these fisheries concerning maximum catch composition percentages are accordingly no longer in force (http://naturerhverv.dk/fileadmin/user_upload/NaturErhverv/Filer/Fiskeri/Erhvervsfiskeri/Discardforbud/Vejledning_til_landingsforpligtelsen_-_industri_og_pelagisk_-_Nordsoeen__Skagerrak_og_Kattegat_V1.pdf). However, according to the Danish national management of the Discard Plan under the EU (Danish) TAC-Quota Regulation for 2016 (European Union Newsletter 28th Jan. 2016 (DA) L22/87) then there can with reference to the landing obligation be included only up to 5% of whiting when maximum 9% of the Norway pout quota consists of by-catch of the species covered by Article 15, point 8, in the EU regulation EU/1380/2013.

The Norwegian technical regulations are generally designed to avoid catches of non-targeted species and/or fish below the minimum size. The discard ban on commercially important species is considered a cornerstone of this policy. Norwegian technical regulations are summarised in "Regulations relating to sea-water fisheries" of 22 December 2004. This stipulates the discard ban, the percentage composition of the catch that may be legally caught according to area and type of fishing gear being used, the characteristics of fishing gear that may be used in the fishery on certain species or in different areas, the minimum catching sizes and specific measures to limit catches of fish under the minimum catching size, regulations of mesh design, mesh sizes, selectivity devices etc.

When fishing demersal species for human consumption in the North Sea with trawl or Danish seine, it is prohibited to use gear where the mesh size of any part of the gear is less than 120 mm. In the Norwegian saithe fishery in the EU zone 110 mm may be used in accordance to the EU regulation in the EU zone. In the Norwegian North Sea gill net fisheries for cod, haddock, saithe, plaice, ling, pollack and hake it is prohibited to use gill nets where the full mesh size is less than 148 mm. In the Norwegian fishery for anglerfish the minimum mesh size is 360 mm and in the halibut fishery the minimum mesh size is 470 mm.

Norway pout may only be fished as bycatch in the mixed industrial fishery in all areas under Norwegian fisheries jurisdiction

Technical measures

Mesh size regulations in the North Sea and adjacent areas

Use of towed nets of any size mesh is permitted, however according to the mesh size in use there is an obligation to retain only particular species of fish. These tables are a simplified synopsis of measures in Council Regulation 850/98 and Commission Regulation 2056/2001 (EU 1998).

	Conditions for use of towed gear (North Sea and West Scotland)	
Mesh size	Main target species in North Sea	Synopsis of required catch percentages
b.) 16 to 31mm	Norway pout, sprat	Minimum 60% of one species of Norway pout, sardine, sandeel, anchovy, eels, smelt and some non-human consumption species (with no more than 5% of cod, haddock or saithe, and some upper limits on the percentages of other species such as mackerel, squids, flatfish, gurnards, Nephrops), or at least 90% of any two or more of those species.

According to the Appendix (Bilag) 6 Note (Meddelelse) from October 2012 from the Danish Ministry of Food, Agriculture and Fisheries, according to the general rules set in the Ministry Regulation (Bekendtgoerelse) No. 1222 of 16 December 2011 § 2, it is from 15th October 2012 obligatory for all Danish vessels participating in the targeted Norway pout fishery in the North Sea and Skagerrak-Kattegat to use a 35 mm grid in the small meshed trawl gears used in the fishery (typically with cod-end mesh sizes 16-31 mm). The grid needs to be in accordance with the following technical specifications: Solid grid in steel, plastic, glass fibre or nylon with minimum 35 mm bar width, and the grid has to be mounted in a net section in front of the cod-end where it covers the full cross area of the section and with an opening which allows escapement of fish which cannot pass the grid.

The difficulty here has been to develop a robust selective grid with smaller grid bar widths to be used in the Danish trawls in order to reduce by-catch of especially other smaller gadoids (in the areas where the Danish fishery operate) compared to the Norwegian trawls where the main aim is to reduce the by-catch of especially larger saithe in the areas where the Norwegian fishery operate.

Norway has since 2010 implemented a regulation with demand of use of selection grids with larger bar widths (40 mm) in trawls used for fishing Norway pout and blue whiting in order to reduce by-catches of other species, especially saithe.

Areas closed to some fishing activities

During the 1960s a significant small meshed fishery developed for Norway pout in the northern North Sea. This fishery was characterized by relatively large by-catches, especially of haddock and whiting. In order to reduce by-catches of juvenile roundfish, the "Norway pout box" was introduced where fisheries with small meshed trawls were banned. The UK Government set up the closure in 1977, prohibiting the fishery of the small mesh size bottom trawl in the area, in order to protect the juveniles of haddock, whiting and other roundfish and to increase the recruitment. The UK Government ratified the statutory instru-ment setting up an area closure of the Norway pout fishery in Feb 1977. In 1986 the closure was included in EC legislation (Regulation 3094/86, Article 27) and further consolidated in Council Regulation (EC) 850/98.

Accordingly, the "Norway pout box" has been closed for industrial fishery for Norway pout since 1977 onwards (EC Regulation No 3094/86). The box includes roughly the area north of 56° N and west of 1° W (see **Figure 26**). Within the Norway pout box as defined in Article 27 of Regulation (EC) 850/98 (see Appendix 2.2) it is prohibited throughout the year to retain more than 5% of the catch as Norway pout if they are caught within a large area in the northwestern North Sea (Figure 7.1). The purpose has been protection of juvenile gadoids (mainly cod, haddock, and whiting) caught in mixtures with Norway pout. An overview of the background and the goals with the Norway pout box regulation is given in **Table 12**.

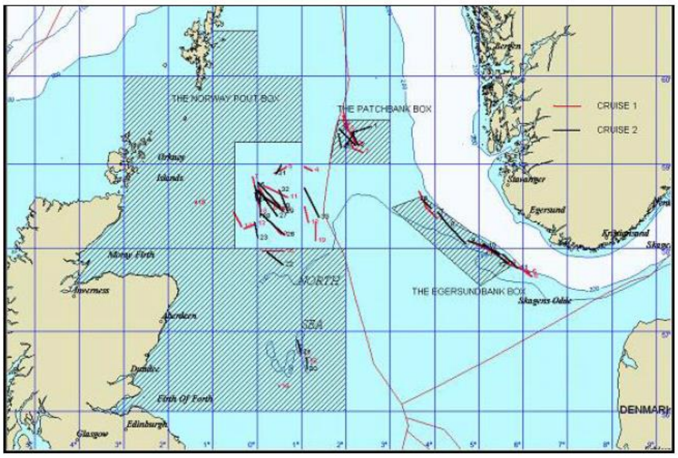


Figure 26. Closure of an area for Norway pout to protect other roundfish (Article 27 of CR 850/89).

In the EU SGMOS meeting in 2007 (EU 2007) it was concluded that it is not possible to fully quantify the effect of the closure of the fishery inside the Norway pout box both with respect to catch rates of target and by-catch species as well as effects on the stocks (EU, 1985; 1987a; 1987b; ICES, 1979). There has not been performed fully covering evaluation of the effect of closed areas in relation to interacting effects of technological development in the fishery including changed selectivity and fishing behaviour over time in relation to by-catch rates. These effects can not readily be distinguished. Existing documentation does not allow for a full quantification of the effects of the closure of the small meshed fishery inside the Norway pout box. Before the closure, the Danish and Faeroes fisheries mainly took place in the northwestern North Sea and the Norwegian fishery in the Norwegian Trench (ICES 1977; EU 2007). Based on IBTS samples for the period 1991-2004 (Figure 6.2 in EU 2007), 30.0% and 27.5% of Norway pout numbers were estimated to be inside the Norway pout box for the first and third quarter, respectively. It should be noted that the IBTS survey does not cover depths >200 m along the Norwegian Trench, and that no fishery inside the Norway pout box may contribute to overestimation of the abundance relative to area outside).

Table 12. Background, goals and objectives of the Norway pout box.

Area	**Characteristics, Location and Seasonality**	**Purpose**	**Defined in Regulation (EC):**
Norway pout box	Prohibited to retain more than 5% of the catch as Norway pout if they are caught within an area boounded by 56°N and the UK coast, 58°N 2°E, 58°N 0°30' W, 59°15' N 0°30'W, 59°15' N 1° E, 60° N 1° E, 60°N 0°, 60°30'N 0°, 60°30'N and the coast of the Shetland Islands, 60°N and the coast of the Shetland Islands, 60°N 3°W, 58°30'N 3°W 58°30'N and the coast of the mainland UK.	Protection of juvenile gadoids (cod, haddock) caught in mixtures with Norway pout)	Article 26 of Regulation 850/98

Table 12. (Continued).

Norway pout box	Goals	Specific objectives	Indices of success	Success criteria
Establishment of the Norway pout box (1977 by the UK Government, 1986 by the EC Regulation 3094/86) To protect certain roundfish species (EC 3094/86)	*Article 27 of Regulation (EC) 850/98* To reduce the fishing mortality on juvenile gadoids such as, haddock, cod and whiting.	*To increase the recruitment of these species to human consumption fishery.* None explicit. *Disaggregated catch rates from IBTS surveys of Norway pout and juveniles of cod, whiting and haddock inside and around the Norway pout box (for preliminary distribution patterns)*	*Catch rates of the same species from commercial fishery around the box based on further disaggregated catch data and from trial fishery with commercial vessels both inside and outside the box* None explicit.	*Reduced fishing mortality of juvenile haddock, cod and whiting.* None explicit *Evaluation of disaggregated CPUE indices from IBTS surveys and commercial fishery inside and outside the Norway pout box, respectively, for Norway pout, cod, whiting and haddock. Provide new data for this.*

The effects of the Norway pout box are not yet thoroughly evaluated (EU 2007). Earlier attempts have proven it impossible to differentiate the effects of the box from the effects of e.g. technological advances and selectivity of gear (Anon. 1987). On the basis of analyses of catch and bycatch data in the Danish Norway pout fishery inside and outside the Box 1975-1986, it was concluded that bycatch of each age group of whiting, haddock and herring depends on location, quarter, year class strength and year within the study period (Anon. 1987). According to this study, bycatch of whiting and haddock dominated in the Norway Pout fishery, and bycatch was shown to be correlated with introduced technical measures, including the Norway pout box and the introduction of the Common Fisheries Policy in 1983. However, changes in bycatch were shown to be linked to differences in yearly and seasonal distribution of Norway pout. Thus, it was from this study not possible to separate area and seasonal effects in relation to quantifying the effect on bycatch by the Norway pout box. In addition, technological development in the industrial fisheries in this decade was not evaluated.

Additional legislation by Norway of closed areas for Norway pout fishery in the Norwegian economic zone covers the Patch Bank (closed since 2002) and the Egersund Bank (closed since 2005) where Norway pout may only be fished as bycatch in the mixed industrial fishery in all areas under Norwegian fisheries jurisdiction. Two areas in the Norwegian economic zone have been closed for fishing on Norway pout, sandeel and blue whiting (**Figure 27**). The approach has been to close areas where the probability of bycatches of juveniles and not-targeted species, such as cod, saithe, haddock, are considered unacceptably high. This measure could therefore also be mentioned as a measure to protect juveniles of other species than Norway pout and sandeel. As of 1 January 2002 the Patch Bank was permanently closed. Before the closure of the Patch Bank an annual average of approximately 2.000 tonnes of Norway pout were fished in this area by Norwegian vessels. As from 1 May 2005 a seasonal closure of the Egersund Bank in the period 1 December to 31 May was determined.

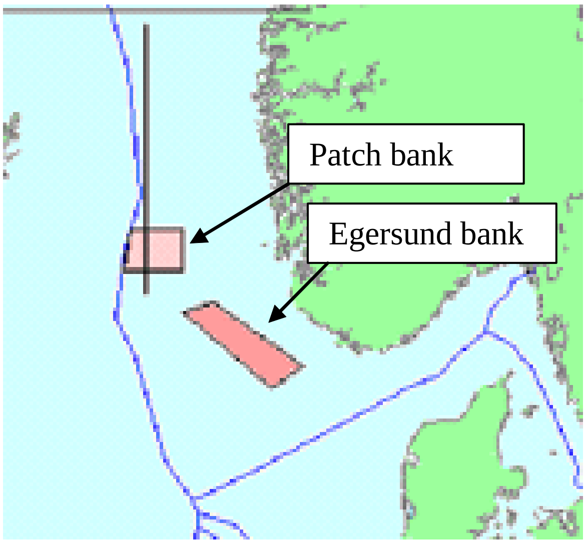


Figure 27. Area closures for Norway pout fishery in the Norwegian economic zone in the North Sea: The Patch Bank (closed since 2002) and Egersund Bank (closed since 2005).

Minimum landing sizes

These sizes are defined in Annex XII to Regulation 850/1998, though some changes are in effect for 2005 by means of the TAC and quota regulation (Regulation 27/2005). Here sizes for some of the main commercial species only are stated.

Species	Minimum Landing Size in 2005, as North Sea/IIIa	Regulation
Norway pout	None	850/1998

4. Quota up-take in the Norway pout fishery

The TAC was not taken in 2008-2010 and 2012-2014, while the small TAC in 2011 was taken. This was likely due to high fishing (fuel) costs in all years as well as bycatch regulations in 2009-2010 and 2013 (mainly in relation to whiting bycatch). There was only less than 30% quota uptake of the ICES adviced TAC for 2012. This low uptake may be explained by the late opening of the fishery at the end of quarter 3 in 2012. In 2013 and 2014, the quota uptake was also below 30%. Individual quotas for the Danish fishery may also play a role in the uptake.

The quota uptake for Norway pout has generally been low with an average yearly uptake of 34% in Denmark. Except for the years 2010 and 2011, where the quota uptake was more than 80%, then the quota uptake has been below 35%. There have been extensive yearly fluctuations in the TACs set for Norway pout with resulting very variable quotas. The relative low quota uptake by Denmark can mainly be explained by the fishermen in years with concurrent high sprat occurrences and quotas in the North Sea has preferred to fish sprat compared to Norway pout because the costs per landed ton of sprat is significantly lower than the costs per ton of landed Norway pout. (Danish Ministry of Environment and Food 2016).

The quota uptake by year and species in the Danish small meshed fisheries for reduction purposes is shown in **Figure 28** where sperling = Norway pout, tobis = sandeel, and brisling = sprat.

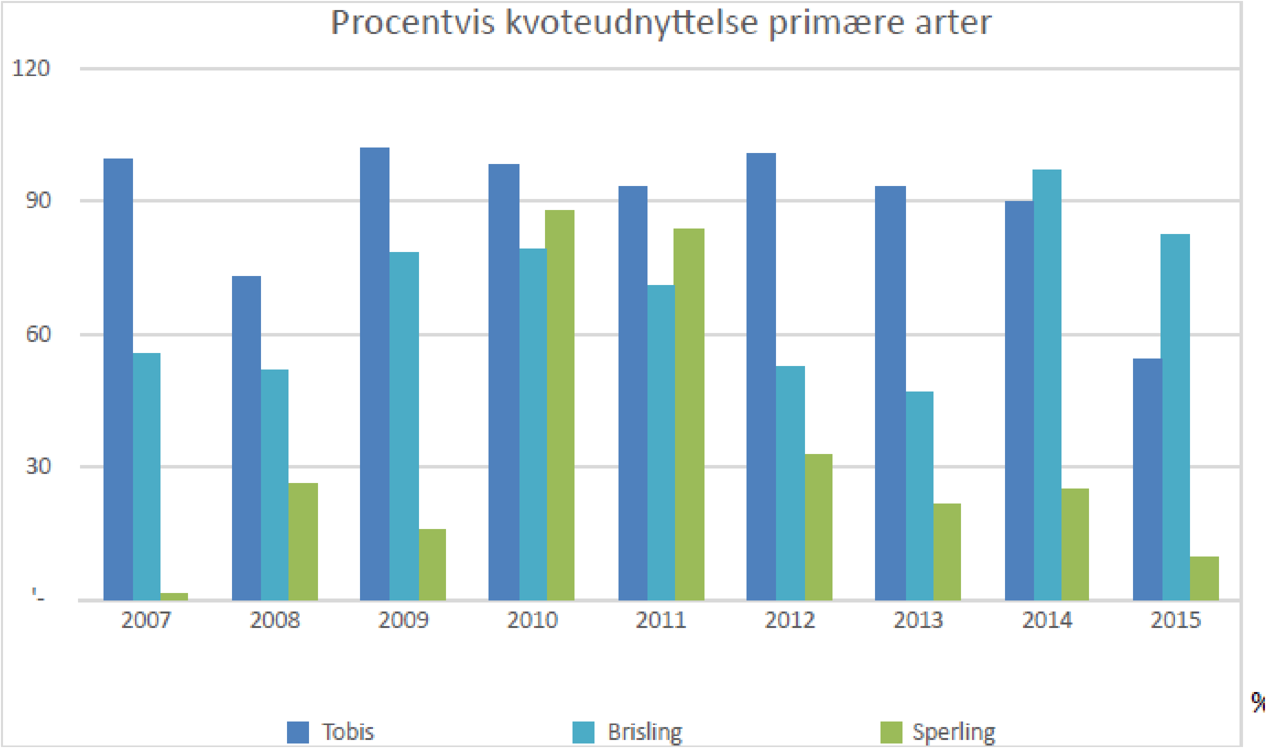


Figure 28. Quota uptake (%) of species by year targeted in the Danish small meshed fisheries for reduction purposes. Sperling = Norway pout, tobis = sandeel, and brisling = sprat. (Danish Ministry of Environment and Food 2016).

In **Figure 29** there is made a comparison in the quota uptake between Denmark and Norway by year of Norway pout.

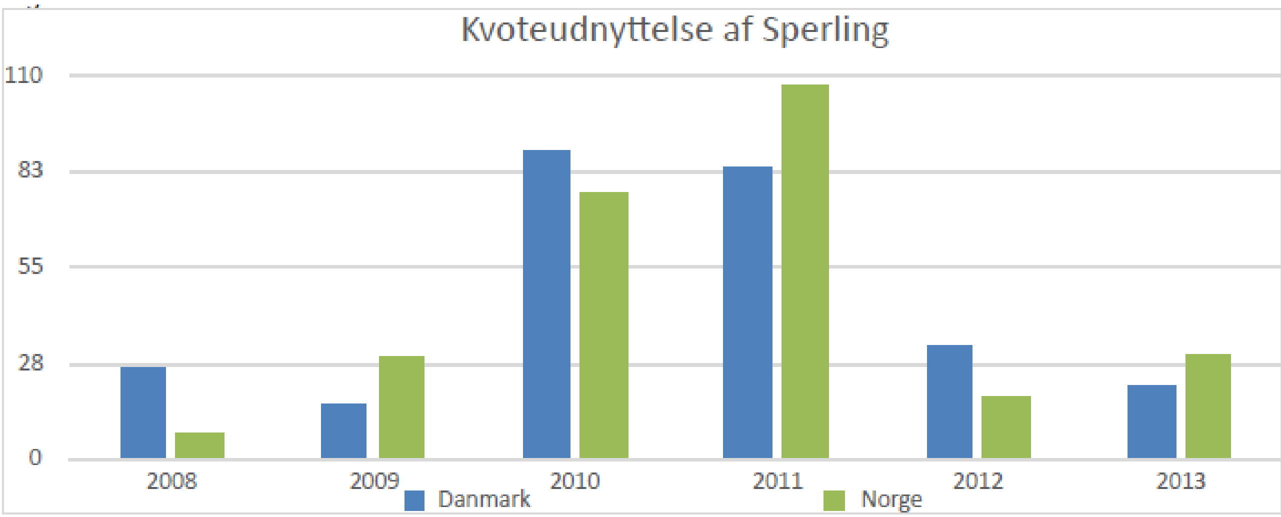


Figure 29. Comparison of the quota uptake (%) of Norway pout (sperling) by year between Denmark and Norway. (Danish Ministry of Environment and Food 2016).

5. Mean weight at ages used in the catch and in the commercial tuning fleet and in the stock

Mean weight at age in catch

The mean weight at age in the catch is based on observations, i.e. samplings from commercial fishery (see sampling section A.3 above), since 1984 onwards (**Fig. 30**). Mean weight at age in the catch is estimated as a weighted average of Danish and Norwegian data. Mean weight at age in the catch is shown in the yearly assessment reports including the historical levels, trends and seasonal variation in this. Mean landings weight at age from Danish and Norwegian fishery from 2005-2008 as well as for 2011 are uncertain because of the few observations. Missing values have been filled in using a combination of sources, values from 2004, from adjacent quarters and areas, and from other countries within the same year, for the period 2005-2008, and in first half year 2010, and for 2011 there has also been used information from other quarters. Also, mean weight at age information from Norway has in 2011 involved survey estimates. The assumptions of no changes in weight at age in catch in these years do not affect assessment output significantly because the catches in the same period were low. Mean weight at age data is available from both Danish and Norwegian fishery in 2009, second half 2010, second half 2011, second half 2012, and all of 2013, 2014 as well as in 2015 and 2016.

The mean weight at age used in the commercial tuning fleet by quarter for the period 1983-2006 in the assessments from 2006-2015 (where the commercial tuning fleet has been used in the assessment) is shown in the yearly assessment reports and in **Figure 31.** It appears that mean weight at age in the commercial tuning for fleet 1 for age group 2 in 4th quarter of the year is very low.

As the abundance (number of individuals) in the tuning indices as well as the number of fish in the catches by age group (catch numbers) are calculated by raising the weights of the samples with the total catch weights, the catch in numbers and the numbers of individuals in the indices are influenced directly by the mean weight at age estimates used. Accordingly, if the mean weight at age is too low then this will positively bias the abundance estimates used as input in the assessments (numbers at age in catch and CPUE in the indices).

Figure 30. NORWAY POUT IV and IIIaN (Skagerrak). Weighted mean weights at age in catch of the Danish and Norwegian commercial fishery for Norway pout by quarter of year during the period 1983-2015. (From the ICES WGNSSK Sep. 2015 Norway pout Assessment).

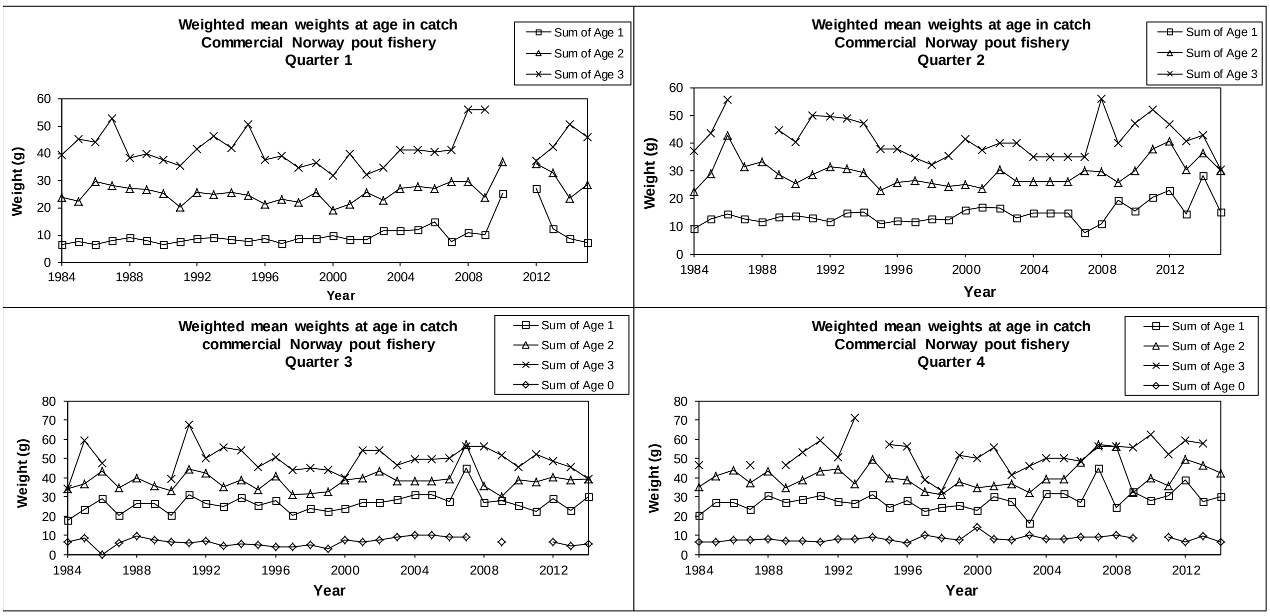
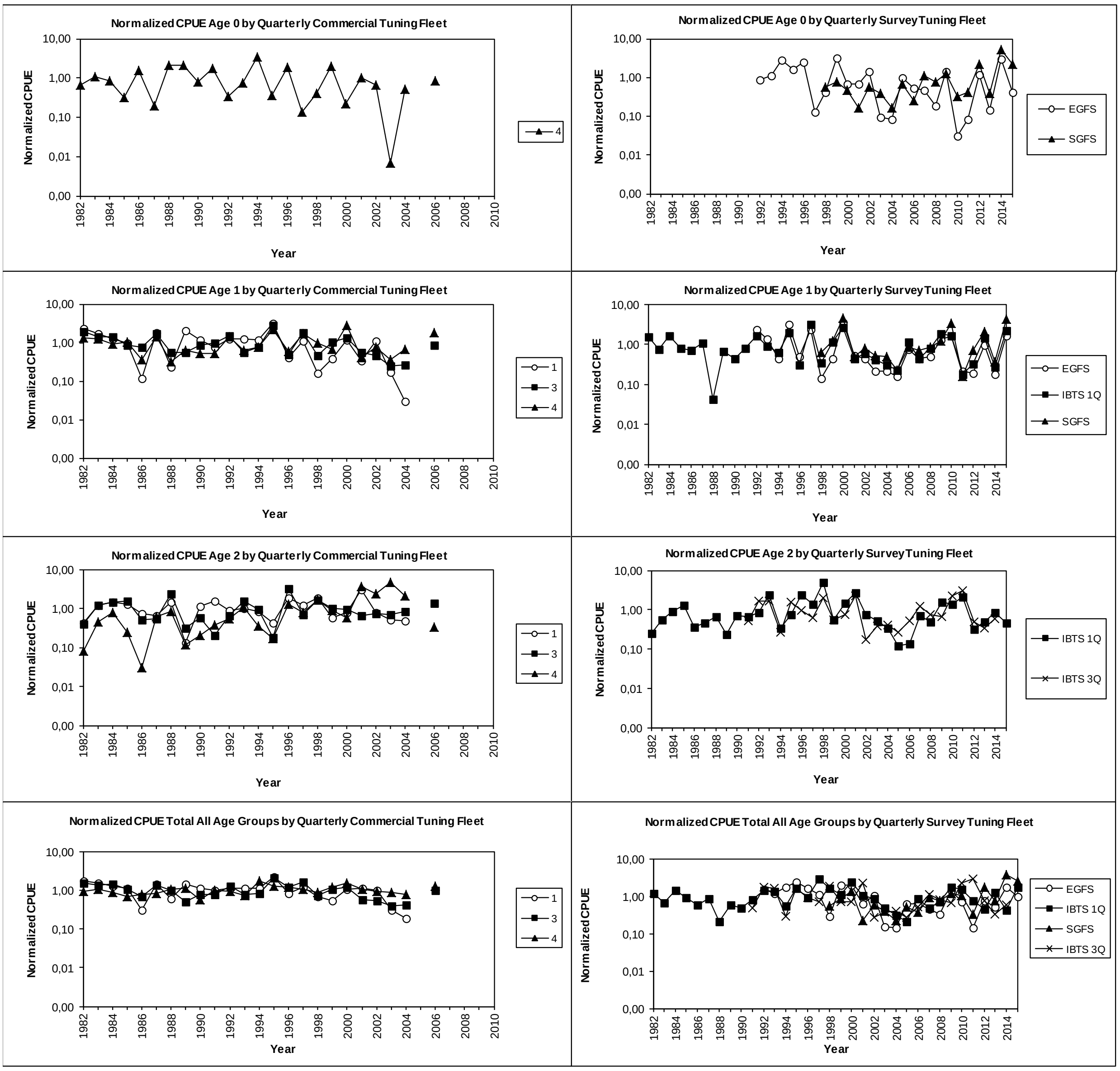


Figure 31. NORWAY POUT IV and IIIaN (Skagerrak). Trends in CPUE (normalized to unit mean) by quarterly commercial tuning fleet and survey tuning fleet used in the Norway pout SXSA assessment for each age group and all age groups together. (From the ICES WGNSSK Sep. 2015 Norway pout Assessment).



Mean weight at age in the stock

The Inter-benchmark assessment in spring 2012 (IBPNorwayPout, ICES 2012c) introduce revised estimates of mean weight at age in the stock used in the Norway pout assessment. The background and rationale behind the revision of mean weight at age in the stock is described in the IBPNorwayPout report (ICES, 2012c) and primary literature (e.g. Lambert et al., 2009).

The same mean weight at age in the stock is used for all years, and mean weight at age in catch is partly used as estimator of weight in the stock. This has resulted in slightly changed levels of constant mean weight at ages in the stock which have been calculated partly from long term averages of mean weight at age in the catch. No major revision of mean weight at age in the stock has been performed compared to the values used in previous assessments. The estimation of mean weights at age in the catches and the used mean weights in the stock in the assessment is described above.

The revised Mean Weight at Age (MWA) in the stock used in the benchmark assessment were for the 1-, 2- and 3- groups taken as the long term averages from the commercial data. Data for MWA by quarter for age 0 were kept constant as used in the Baseline. MWA was recorded from commercial fishery catch data, but not from the IBTS, from which only length data are available. The revised MWA in the stock was applied in assessment scenario runs as obtained from long term averages measured from the commercial fishery catch. The changes in MWA were minor compared to the Baseline and did not have much impact on the assessment results.

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Working document to WKPOUT 2016

Norwegian industrial fishery for Norway pout in the North Sea

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Summary

The Norwegian industrial trawl fishery in the North Sea is a mixed fishery carried out using demersal trawls with small meshed codend (minimum 16 mm meshes), where the main fishing areas in the Norwegian exclusive economic zone (NEEZ) are along the western part of the Norwegian Trench. In EU-waters, the fishery is carried out on the Fladen Ground and east of Shetland. Norway pout and blue whiting are the main target species, but the landings of Norway pout is typically larger than the blue whiting landings. To reduce the amount of by-catches the fishery has been regulated with area and seasonal restrictions and by-catch limitations. From 2010, selection grids have been used to reduce the by-catch of larger gadoids, however, some vessels (7 vessels) have been allowed to trawl without using selection grid as they are equipped to deliver larger fish for human consumption. From 2016, all vessel staffed and equipped to deliver large fish are allowed to fish without selection grid. The number of vessels with industrial trawling license has dropped over the years, from about 99 in 2002 to 29 in 2016. At the same time, the average vessel size and engine power have increased markedly.

Description of the fishery

According to the Norwegian regulations the Norwegian industrial trawling for Norway pout can be carried out in Skagerrak and south of 64°N in the North Sea. However, target trawling for Norway pout is not allowed north of 62°N as the Norwegian regulations prohibit trawling with small meshed trawls for species as cod, haddock, whiting and saithe north of this latitude.

The Norway pout fishery is carried out by licensed industrial trawlers, which target blue whiting and Norway pout, often at the same trip. The license system is complex, and the different vessels have different species quotas and some vessels take out the large fish such as saithe, cod, monkfish, hake and others from the catch and deliver for human consumption. The fishing strategies differ between vessels, as some vessels take most of their blue whiting quota west of Ireland, whereas others save their quota to be able to carry out a mixed blue whiting – Norway pout fishery in the North Sea. Some vessels have also a license to target Atlantic argentine (*Argentina silus*) north of 62°N. From the landing statistics it seems like some vessels also target horse mackerel, herring, blue whiting and herring in the same trip that can last as long as up to 9 days.

The landings of Norway pout are very low from January to May as the trawlers are occupied with other fisheries. After the end of the sandeel fishery in May/June, some of the industry trawlers start the Norway pout fishery.

Geographical distribution of effort by quarter is presented in Figure 1, where data are extracted from the Norwegian Directorate of Fisheries logsheet database. The maps show all hauls carried out in the period 2011-2015 for the Norwegian industrial trawlers where Norway pout or blue whiting is defined as target species and where more than 1 ton in the catch has be registered as Norway pout. From 2011, it has been mandatory for industrial trawlers (and other larger fishing vessels) to submit electronic logsheets. For the previous years, no logsheet data are electronically available for the industrial trawlers. The main trawling activity is along the western part of Norwegian Trench south of 60°30', on Fladen ground and in the area east of Shetland (Figure 1).

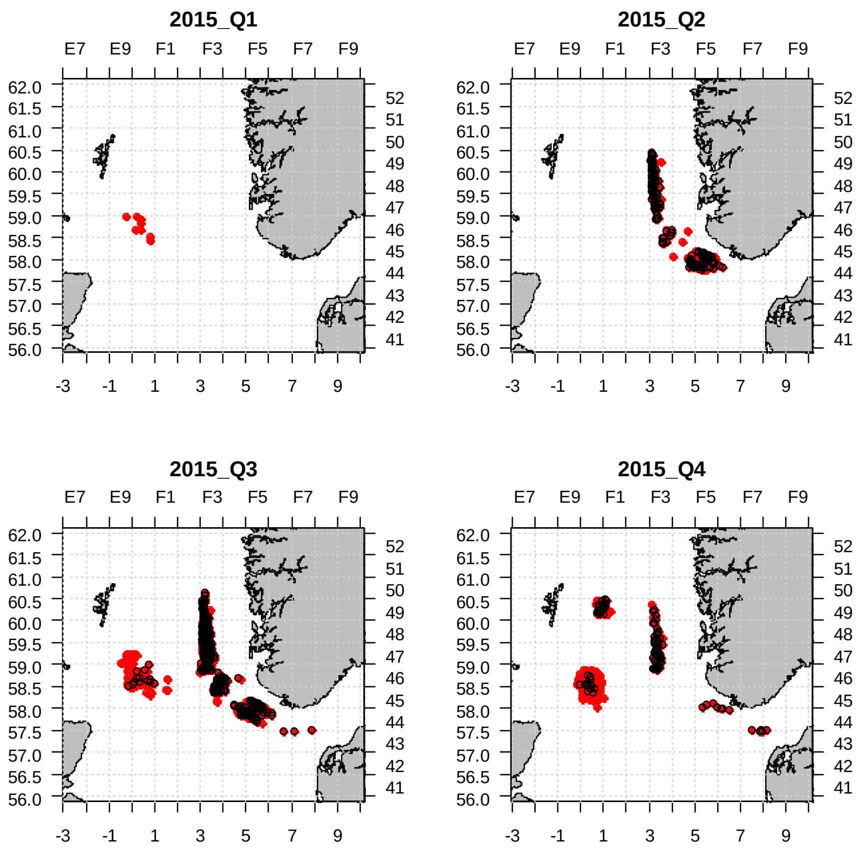
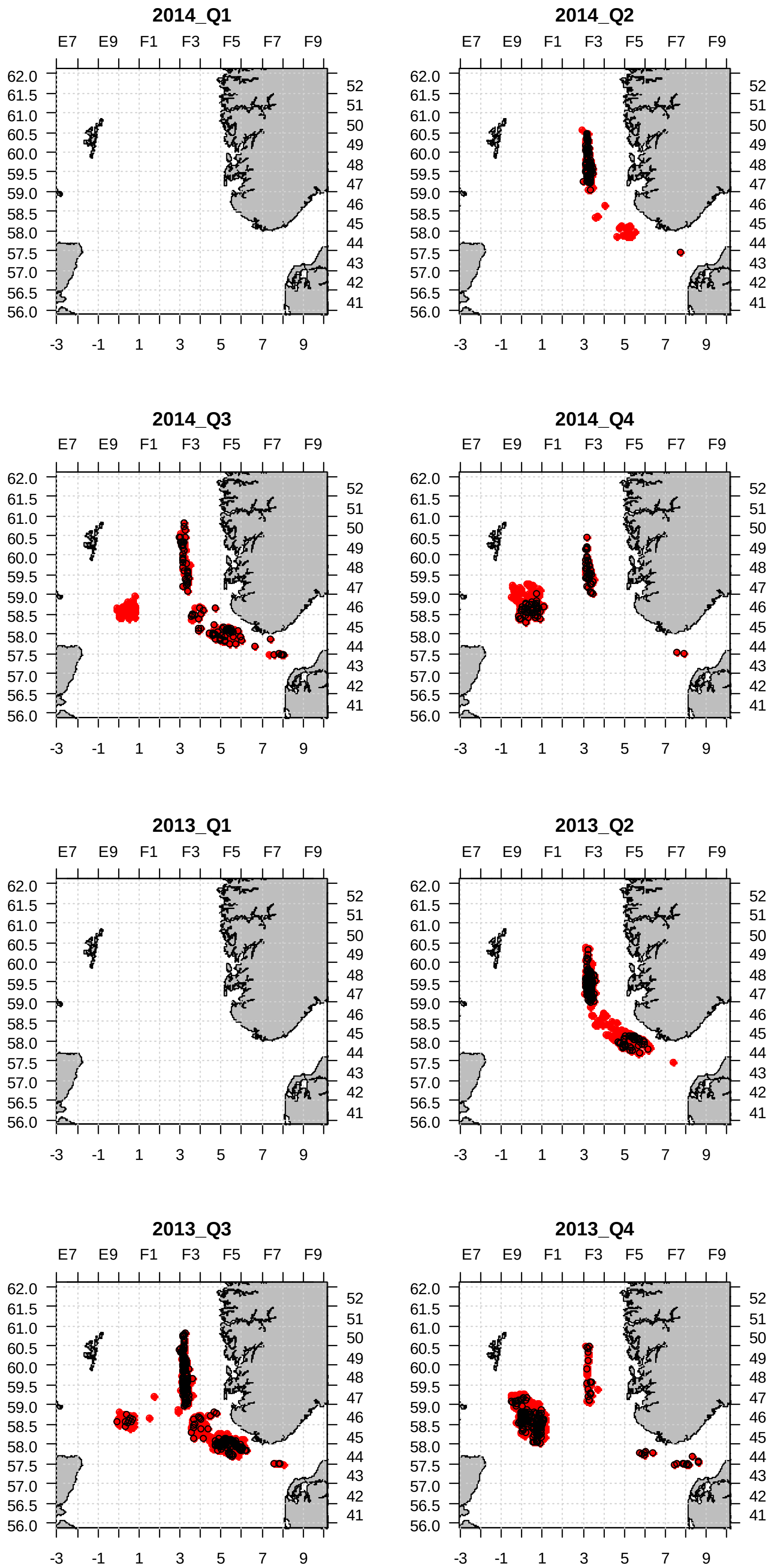
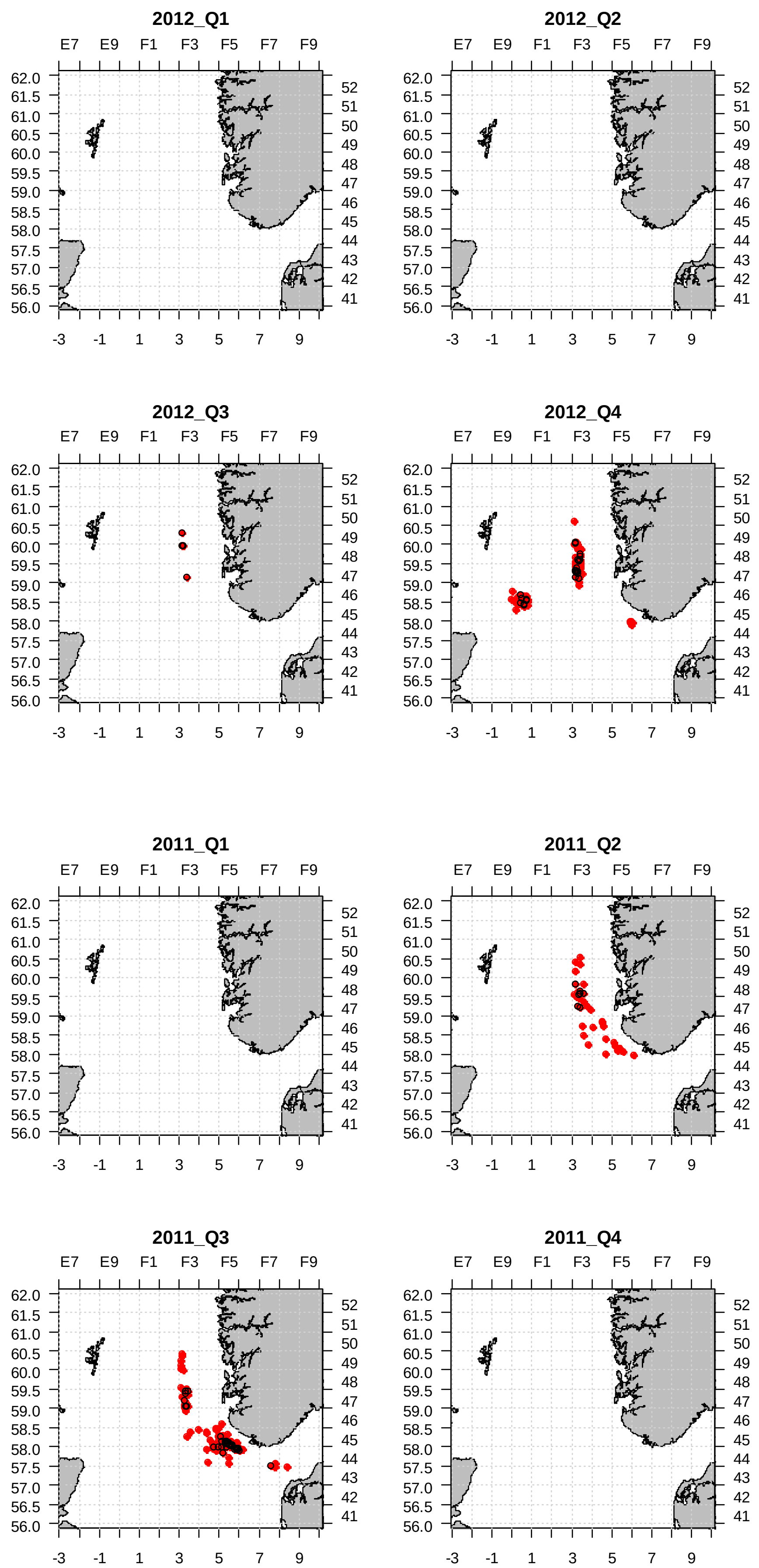


Figure 1 Geographical distribution of trawl hauls where Norway pout is the target species. Information is collected from the Norwegian logsheet database. Red dots represent vessels using selection grid, and black circles are vessels that are allowed to trawl without selection grid.



2014_Q1
2014_Q2
2014_Q3
2014_Q4
2013_Q1
2013_Q2
2013_Q3
2013_Q4
E7 E9 F1 F3 F5 F7 F9
62.0 61.5 61.0 60.5 60.0 59.5 59.0 58.5 58.0 57.5 57.0 56.5 56.0
52 51 50 49 48 47 46 45 44 43 42 41
-3 -1 1 3 5 7 9


2012_Q1
2012_Q2
2012_Q3
2012_Q4
2011_Q1
2011_Q2
2011_Q3
2011_Q4
E7 E9 F1 F3 F5 F7 F9
62.0 61.5 61.0 60.5 60.0 59.5 59.0 58.5 58.0 57.5 57.0 56.5 56.0
52 51 50 49 48 47 46 45 44 43 42 41
-3 -1 1 3 5 7 9

Regulations

Many of the regulations for the Norwegian industrial trawling in the North Sea (targeting Norway pout and blue whiting) are in place to reduce the large by-catch problems. Studies show that the catch from a single fishing trip can consist of almost 40 species (Anon 2013).

Selection grid

From 1 May 2010 all trawlers targeting Norway pout in NEEZ had to use selection grid with a grid distance of 40 mm. However, a small number of vessels (7 vessels) were allowed to catch Norway pout without using selection grid as they had equipment and historical tradition of take out and deliver larger fish for human consumption. From 2016, all vessels staffed and equipped to deliver large fish are allowed to fish without selection grid. A considerable number of vessels have rebuilt their onboard production line to be able to sort out large fish, and per 15th of July 2016 12 vessels can fish without selection grid. Note that some vessels will test twin-trawls in 2016 to improve the catch-rates. From 2016, according to TAC-agreement between Norway and EU, all Norwegian industrial trawlers fishing Norway pout in EU waters (ICES area IV) have to use a selection grid with a minimum grid distance of 35 mm.

Seasonal regulations

The industrial fishery in NEEZ in the North Sea is open from 1st of April to 31st of October, but some important fishing grounds have additional seasonal closures (see below) when the abundance of herring and gadoid juveniles can be high in these areas.

Closed areas

The Egersund bank is closed for all small mesched trawl fishery 01.10 – 31.05. Implemented 1 January 2003. Until 2006 the closed season was 01.12-31.05.

Geographical position:

1. 58°37'N 03°44'Ø
2. 57°49'N 05°48'Ø
3. 57°33'N 05°02'Ø
4. 58°29'N 03°02'Ø

The Patch bank was closed for industrial trawling from 1 January 2002

Geographical position:

1. 59°30'N 01°50,3'Ø
2. 59°30'N 03°00,0'Ø
3. 59°00'N 03°00,0'Ø
4. 59°00'N 01°38,4'Ø

By-catch limitations

The maximum bycatch of cod, haddock and saithe in industrial trawling in the North Sea is maximum 20% in weight by haul and by landing. The bycatch of herring is maximum 10%, Any bycatch of herring is taken from the vessel quota. The bycatch of greater argentine is maximum 10%. Maximum bycatch of monkfish is 0.5%, and landing of monkfish by trip should not exceed 500 kg. Only vessels with quota of blue whiting are allowed to conduct small meshed industrial trawling.

Official landing statistics and control of species composition

For all landings, the skipper and the representative of the landing site sign the sales note where the landing is reported by species. The sales notes form the basis of all official landing statistics. When the landing is controlled by the Directorate of Fisheries, the species-composition (in weight) is recorded, and the skipper and the landing-site representative get access to this measured species-composition to use in the signed sales note. If the landings are not controlled, the species composition from the electronic logbook is given at the sales notes. According to plan, about 20% of all industrial fishing landings in numbers are supposed to be controlled. However, the proportion of controlled samples has decreased in the recent years, and in some quarters no controls have been carried out at all. The low number of controls, in combination with large variation in fishing strategies make it difficult to estimate the actual catch composition taken by the Norwegian industrial trawlers in the North Sea. In addition to controls at the landing site, the Norwegian Coast guard have inspection of hauls at sea, however, these inspection is often done in areas known to problematic with regards to by-catch of herring and juveniles of gadoids.

Table 1. Problems with the Norwegian landing statistics of Norway pout

Description	**References**
The species diversity in the landings notes is generally much lower than observed in controls and studies.	Appendix 1 (In Norwegian). Kvalsvik et al. 2006
The sub-sampling of the landings is difficult, and studies show that large individuals are under-represented in the samples as the sub-sample device at the landing site does not sort out large fish.	”Prøvetaking av industriråstoff og seddelskriving ved landing Forslag til forbedringer - Forslag til forbedringer” (Anno 2013)
Too low number of controls, and too few sub-samples when the landings are small or medium.	”Prøvetaking av industriråstoff og seddelskriving ved landing Forslag til forbedringer - Forslag til forbedringer” (Anno 2013)
Some of the landings are delivered in Denmark with no control of the catch composition	

Due to the problems mentioned above, the official landings of Norway pout, blue whiting and by-catches species taken by the industrial trawlers in the North Sea cannot not be considered reliable. Furthermore, the low number of controls and problems with the sub-sampling it is difficult to estimate a trustworthy modified landing of Norway pout. The controls, and studies at sea and personal communication with people working with the controls give the impression that the official landing of Norway pout is an overestimate in years with high quotas of Norway pout.

Effort analyses

Table 2 shows that the number of Norwegian vessel with industry trawling license has been reduced from almost 100 in 2001 to 29 in 2016. At the same time, the number of active Norway pout trawlers has been reduced from 37 to 17, and the average horse power of the active Norway pout trawlers has increased from 1205 to 3214. These numbers reflects the marked restructuring of the fleet, which makes it difficult to standardize effort for the last 15 years.

Table 2. Historical changes in number of vessels and engine powers (of those that are fishing)

Year	No. Vessels with licence	No. Active vessels (Annual landing > 50 t)	Mean HP
2001	97	37	1205
2002	99	39	1276
2003	74	22	1390
2004	70	16	1417
2005	68	2	1620
2006	57	24	2006
2007	58	16	1720
2008	45	10	1940
2009	43	15	2442
2010	41	29	2852
2011	39	6	2075
2012	36	13	2240
2013	35	27	2754
2014	36	17	2488
2015	30	17	3214
2016	29		

Furthermore, it is difficult to normalize effort as the vessels may target different species during the same trip. Logsheet data shows that the ratio of Norway pout in a haul is seldom 100% (Figure 2), and a vessel may operate in different bottom depths targeting different species. As the Norwegian industrial fishery (exclusive the sandeel fishery) in the North Sea is a mixed species fishery, the catch rates of Norway pout is in addition to abundance of Norway pout affected by fishing strategies to utilize quotas of other species such as blue whiting, saithe, horse mackerel etc.

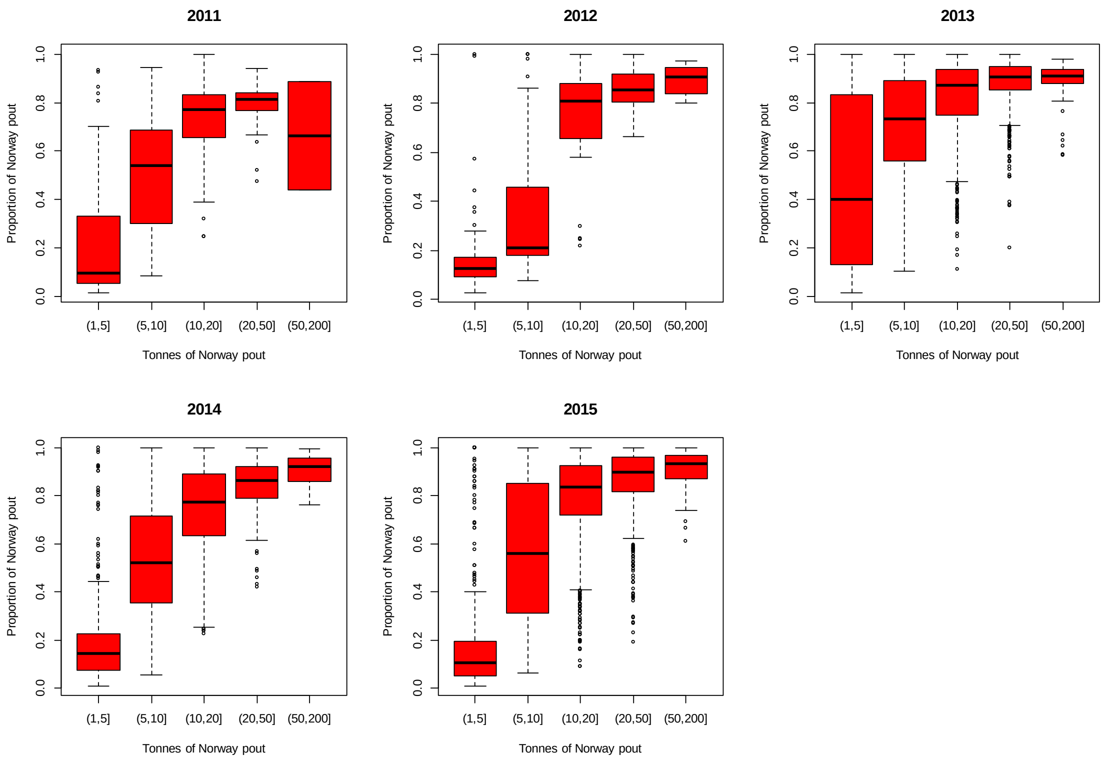


Figure 2. Boxplot of proportion of Norway pout by haul taken by the industry trawlers where the target species is blue whiting or Norway pout and the catch of Norway pout is > 1000 kg by haul.

References

Kvalsvik, K., Huse, I., Misund, O. A., & Gamst, K. (2006). Grid selection in the North Sea industrial trawl fishery for Norway pout: Efficient size selection reduces bycatch. *Fisheries research*, *77*(2), 248-263.

Anon 2013. Provetaking av industrirastoff og seddelskriving ved landing - Forslag til forbedringer. (In Norwegian) http://www.fiskeridir.no/content/download/8733/106501/version/2/file/rapport-industriraastoff-og-seddelskriving-ved-landing.pdf

Artssammensetning og lengdefordeling i industrifisket med småmasket trål etter målartene øyepål og kolmule – fartøy med dispensasjon fra ristpåbudet

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Innledning

Fiskeridirektoratet (FDir) startet et prosjekt i 2014 på kartlegging av artssammensetning og lengdefordeling om bord på fartøy som tråler etter industrifisk som landes til mel- og oljeproduksjon. Prosjektledere har vært Robert Misund og Geir Blom. Fra juli i år har det blitt gjennomført tokt om bord på tre ulike fartøy som har dispensasjon fra ristpåbudet. Denne dispensasjonsordningen innebærer at fisk som er egnet til konsum skal sorteres ut og sløyes, og resten går på tank. Fiskearter som normalt benyttes til konsum er: sei, torsk, lyr, lange, lysing, breiflabb, gråsteinbit, smørflyndre og kveite. Konsumfisken har ofte en lengde som er større enn de respektive minstemålene.

Formålet med prosjektet var å analysere artssammensetning og lengdefordeling på fisk som går på tank i industrifisket med småmasket trål etter øyepål og kolmule. Undersøkelsene har blitt utført om bord på én tur med tre ulike fartøy som har dispensasjon fra ristpåbudet i perioden juli til september 2014.

Materiale og metoder

Robert Misund organiserte toktene om bord på de tre fartøyene. Geir Blom utarbeidet prosedyren for prøvetaking av artssammensetning og opparbeiding av lengdeprøver som ble benyttet. Personellet på de tre toktene var: Robert Misund og Leif Åge Larsen – Overvåkningstjenesten (OVT)(Tokt 1), Geir Blom og Edd A. Ingebrigtsen - OVT (Tokt 2) og Lise Langård og Arnt-Magnus Gamst - OVT (Tokt 3).

Industrifisken ble tatt med småmasket trål om bord på de tre fartøyene. Det ble gjennomføret to trålhal per døgn der hvert hal varte mellom 5 og 7 timer. Det ble ikke trålt om natten.

På to av fartøyene ble fisken pumpet om bord, og på ett fartøy ble fisken sekket om bord. Konsumfisk ble frasortert etter hvert som fisken ble pumpet eller sekket om bord. Resten av fisken gikk på transportbånd til lagringstankene. Prøvetakingen av fisk som gikk på tank bestod i å fylle korg for korg med fisk fra fiskestrømmen på båndet. Det ble tatt ut 3 delprøver fra hvert trålhal, der hver delprøve bestod av 1 eller 2 korger (ca. 30 kg per korg) med materiale, avhengig av størrelsen på halet (2 korger per delprøve hvis halet var større enn 30 tonn). Det ble tatt ut en delprøve fra begynnelsen (delprøve 1), midten (delprøve 2) og slutten (delprøve 3) fra hvert hal.

Fisken i hver delprøve ble sortert til art, og evertebrater til art eller familie, orden eller klasse. Hver kategori ble veid separat til nærmeste 1 g eller 10 g på en Marel vekt. Lengden av fiskearter (målarter) som øyepål, kolmule, sølvtorsk, strømsild osv. ble målt til nærmeste 0,5 cm nedad på et målebrett. Andre fiskearter ble målt til nærmeste hele cm nedad. Det ble lengdemålt mellom 14 til 100 individ av tallrike arter fra hver korg. Hvert individ av en art ble lengdemålt hvis det var < 25 individ av en fiskeart i en korg.

I tillegg ble det benyttet sporingsdata og data fra den elektroniske fangstdagboken (ERS) i den videre analysen av dataene fra toktene.

Tabell 1 gir en oversikt over når toktene ble gjennomført, område(r) der fangsten ble tatt, antall trålhal, totalt prøveuttak, estimert kvantum på tank og antall arter registrert i fangsten på toktene.

Tabell 1. Oversikt over områdene trålhalene ble utført, perioder for undersøkelsene, antall trålhal undersøkt, estimert kvantum på tank og antall arter registrert på hvert av de tre toktene som har blitt gjennomført i 2014 med pelagiske trålfartøy som har dispensasjon fra ristpåbudet. * = Trålposen revnet på det ene halet, og det ble derfor ikke tatt prøver fra dette halet.

Tokt	Områder	Periode	Antall trålhal undersøkt	Kvantum prøve (kg)	Estimert kvantum på tank (tonn)	Antall arter registrert
Tokt 1	Egersundbanken	17.-21. juli	9 (10)*	1 149	293	12
Tokt 2	Rotteholet og Egersundbanken	14.-17. august	8	830	107	37
Tokt 3	Egersundbanken	6.-10. september	10	837	151	18

Rådataene ble lagt inn i Excel-ark av Geir Blom og Modulf Overvik, og førstnevnte har også analysert dataene som er samlet inn og skrevet rapporten.

For hver delprøve ble vektene av hver kategori summert sammen til total vekt per delprøve. Prosentandelen av hver kategori i en delprøve ble så beregnet. Dette gav 3 ulike prosentandeler (P) per kategori ($K_{1,\,n}$) per hal:

K_1Pa, K_1Pb og K_1Pc,…, K_nPa, K_nPb, K_nPc der *n* er antall kategorier (arter), der Pa = % i delprøve 1, Pb = % i delprøve 2 og Pc = % i delprøve 3.

Gjennomsnittlig artssammensetning (vekt og %) på tank for hvert av toktene ble kalkulert etter følgende prosedyre:

Først ble de 3 ulike (prosent)andelene per kategori per hal multiplisert med sum vekt (V_{Sum}) per hal fra ERS. Dette gav 3 ulike vektestimater (Va,Vb og Vc) av hver kategori ($K_{1,\,n}$) per hal slik at:

1) $V_{Sum} = VaK_1 + VaK_2 + \ldots\ldots\ldots VaK_n$,
2) $V_{Sum} = VbK_1 + VbK_2 + \ldots\ldots\ldots VbK_n$, og
3) $V_{Sum} = VcK_1 + VcK_2 + \ldots\ldots\ldots VcK_n$,

der Va = vekt basert på delprøve 1, Vb = vekt basert på delprøve 2, og Vc = vekt basert på delprøve 3.

Ved å gjøre disse beregningene for hvert hal, og så summere over hal, ble:

4) $$\sum_{H=1}^{H=n} (V_{Sum}) = \left[\sum_{H=1}^{H=n} (VaK_1) + \sum_{H=1}^{H=n} (VaK_2) + \ldots\ldots\ldots \sum_{H=1}^{H=n} (VaK_n) \right],$$

5) $$\sum_{H=1}^{H=n} (V_{Sum}) = \left[\sum_{H=1}^{H=n} (VbK_1) + \sum_{H=1}^{H=n} (VbK_2) + \ldots\ldots\ldots \sum_{H=1}^{H=n} (VbK_n) \right], \text{ og}$$

6) $$\sum_{H=1}^{H=n} (V_{Sum}) = \left[\sum_{H=1}^{H=n} (VcK_1) + \sum_{H=1}^{H=n} (VcK_2) + \ldots\ldots\ldots \sum_{H=1}^{H=n} (VcK_n) \right],$$

der H = trålhal fra 1 til n.

Deretter ble vektandelen (%) av hver kategori ($K_{1,\ n}$) ift. til $\sum(V_{Sum})$ gitt i 4), 5) og 6) kalkulert.

Dermed kunne endelig gjennomsnittlig artssammensetning (vekt og %) på tank for hvert av toktene kalkuleres som:

Gjennomsnittlig vekt per kategori ($SnittVK_{1,n}$) = $[\sum(VaK_1) + \sum(VbK_1) + \sum(VcK_1)]/3$,……………, $\sum[(VaKn) + \sum (VbKn) + \sum (VcKn)]/3$, og

gjennomsnittlig prosentandel per kategori [$Snitt\%(VK_{1,n})$] = $[\%\sum(VaK_1) + \%\sum(VbK_1) + \%\sum(VcK_1)]/3$,……………, $[\%\sum(VaKn) + \%\sum(VbKn) + \%\sum(VcKn)]/3$.

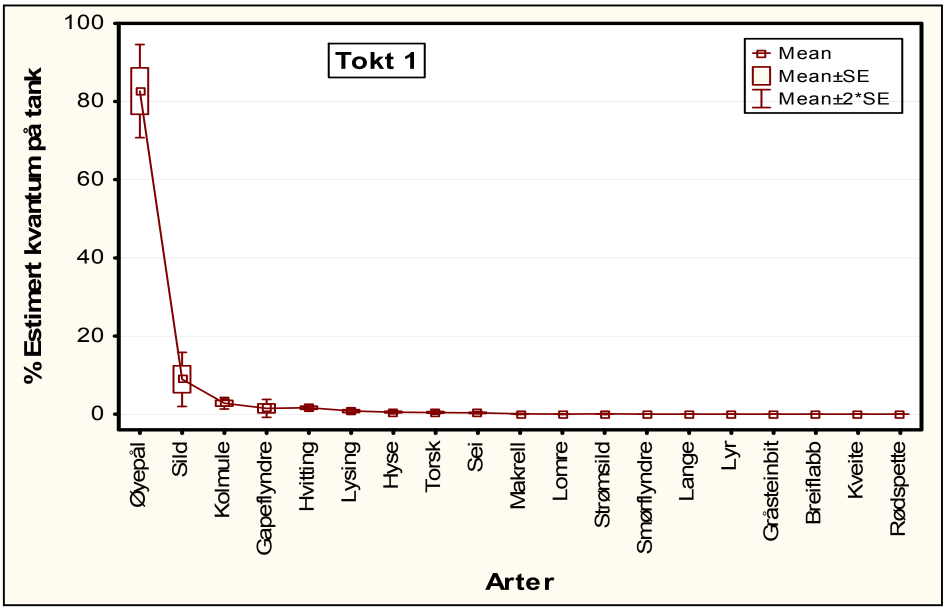
Gjennomsnittlig artssammensetning (vekt og %) med standardfeil (SE) ble kalkulert vha. programmet STATISTICA.

Lengdefordelingene av ulike arter er presentert i histogrammer med informasjon om gjennomsnittlig lengde per art med tilhørende standardavvik, minimums- og maksimumslengder og antall individ lengdemålt. Dette ble også gjort vha. programmet STATISTICA.

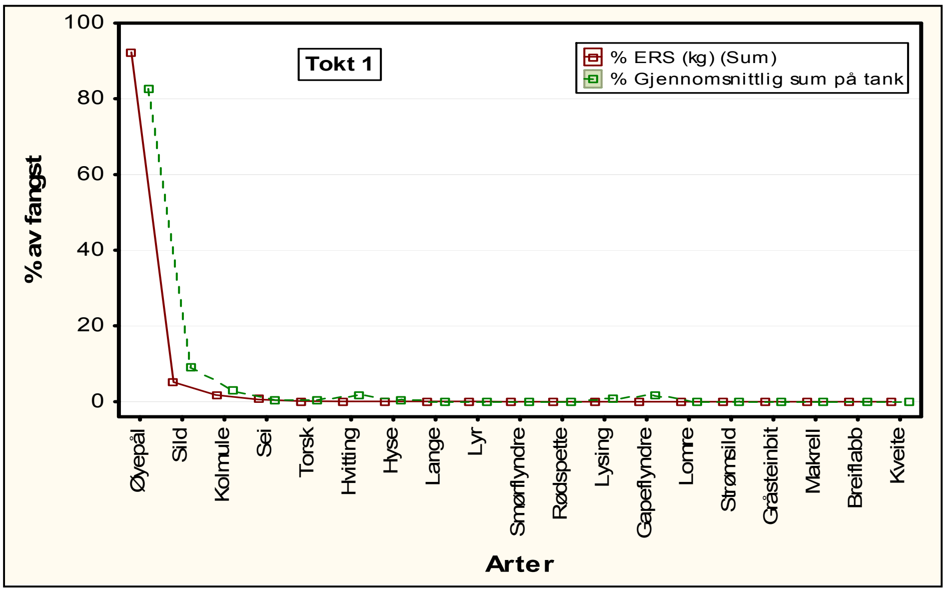
Resultater

Artsammensetning på tank

A.



B.



Figur 1. A. Gjennomsnittlig prosentandel med 1*standardfeil (SE) og 2*SE av arter registrert i fangsten som gikk på tank på Tokt 1. Toktet ble gjennomført på Egersundbanken (9 av 10 hal ble undersøkt) i perioden 17.-21. juli 2014. B. Sammenligning av gjennomsnittlig prosentandel av arter i fangsten som gikk på tank estimert ut fra FDirs målinger av artsammensetning og prosentandel av arter tatt fra ERS på Tokt 1.

Øyepål var den desidert viktigste arten i fangsten på Tokt 1, og det ble kalkulert gjennomsnittlige prosentandeler av øyepål og nordsjøsild på henholdsvis 82,7% og 8,9% i fangsten som gikk på tank (Figur 1A). Summen av sei, torsk og hyse som gikk på tank var 1,4%. Prosentandelen av øyepål var 9,6% høyere i ERS (92,3%) enn den gjennomsnittlige prosentandelen (82,7%) av øyepål i FDirs målinger på Tokt 1 (Figur 1B). For nordsjøsild var prosentandelen 5,1% i ERS mot 8,9% i FDirs målinger.

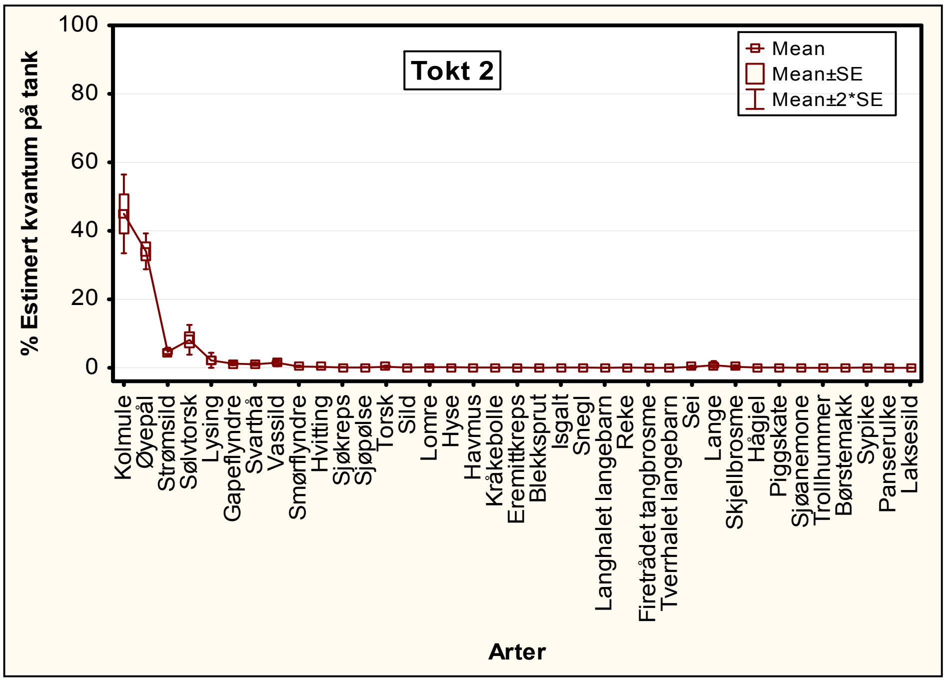
Det ble registrert 12 arter i målingene av artssammensetning på tank (se Tabell 2), og det er antatt 11 arter gitt i ERS på tank. FDirs estimat av øyepål på tank var mer enn 28 000 kg lavere enn det i ERS mens estimatet for nordsjøsild var mer enn 11 000 kg høyere enn det i ERS. Disse forskjellene er betydelige sett i lys av at skipper på Tokt 1 hadde tilgang til FDirs måleresultat av artssammensetningen på tank. For arter som hvitting og gapeflyndre var FDirs estimater mer enn 4 000 kg høyere enn de i ERS (tall for gapeflyndre manglet i ERS).

Tabell 2. Oppsummering av fangst på tank på Tokt 1 med artsfordeling i kvanta og prosent oppgitt i ERS og estimert gjennomsnitt i FDirs målinger basert på data fra 9 hal. Forskjellen i vekt per art på tank mellom FDirs estimat og ERS er gitt i den siste kolonnen i tabellen. Positive forskjeller indikerer et FDirs estimat er høyere enn de i ERS, og negative forskjeller indikerer at FDirs estimat er lavere enn de i ERS. * = Kvanta av konsumarter som antas å ha gått på tank.

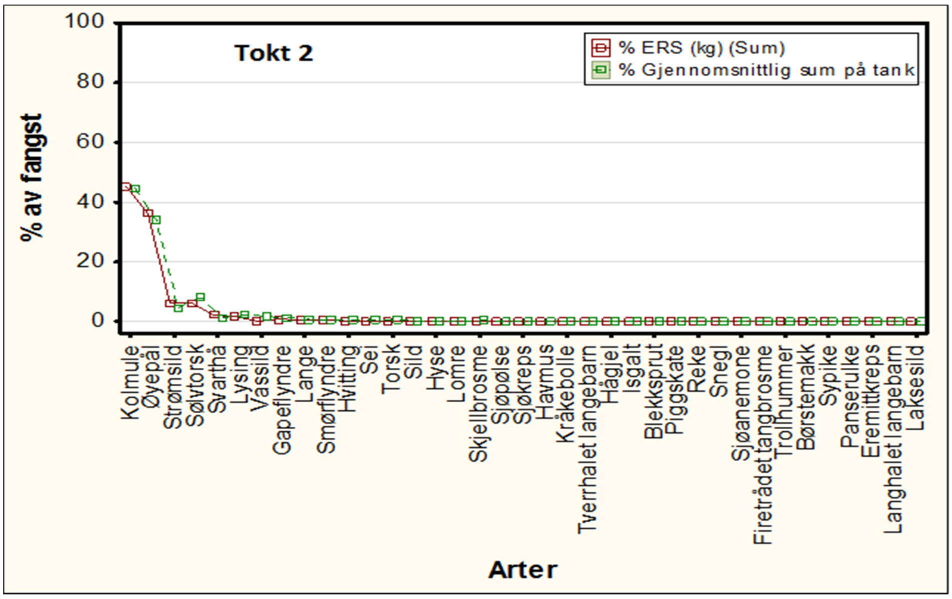
Arter	**ERS (kg)**	**ERS (%)**	**Estimert på tank (kg)**	**Estimert på tank (%)**	**Forskjell (kg)**
Øyepål	270 000	92,29	241 893	82,68	-28 107
Nordsjøsild	15 000	5,13	26 100	8,92	11 100
Kolmule	5 000	1,71	8 183	2,80	3 183
Sei*	1 750	0,60	1 136	0,39	-614
Torsk*	380	0,13	1 297	0,44	917
Hvitting	230	0,08	4 952	1,69	4 722
Hyse	120	0,04	1 627	0,56	1 507
Lange*	40	0,01	0	0,00	-40
Lyr*	40	0,01	0	0,00	-40
Smørflyndre*	3	<0,01	0	0,00	-3
Rødspette*	3	<0,01	0	0,00	-3
Lysing	0	0,00	2 367	0,81	2 367
Gapeflyndre	0	0,00	4 429	1,51	4 429
Lomre	0	0,00	74	0,03	74
Strømsild	0	0,00	240	0,08	240
Makrell	0	0,00	269	0,09	269
Alle	**292 566**	**100,00**	**292 566**	**100,00**	**0**

FDirs målinger av artssammensetning viste at kolmule og øyepål var de viktigste artene i fangsten på Tokt 2, og det ble kalkulert gjennomsnittlige prosentandeler av kolmule og øyepål på henholdsvis 44,9% og 34,0% (Figur 2A). Summen av sei, torsk og hyse på tank utgjorde 0,6 %, og nordsjøsild på tank utgjorde < 0,1%.

A.



B.



Figur 2. A. Gjennomsnittlig prosentandel med 1*standardfeil (SE) og 2*SE av arter registrert i fangsten som gikk på tank på Tokt 2. Toktet ble gjennomført i områdene Rotteholet (6 hal) og på Egersundbanken (2 hal) i perioden 14.-17. august 2014. B. Sammenligning av gjennomsnittlig prosentandel av arter i fangsten som gikk på tank estimert ut fra FDirs målinger av artsammensetning og prosentandel av arter tatt fra ERS på Tokt 2.

Det var generelt god overensstemmelse mellom prosentandeler av ulike arter i ERS og FDirs gjennomsnittlige estimat (Figur 2B). Imidlertid var prosentandelen av sølvtorsk 2,3% høyere i

ERS sammenlignet med FDirs estimat, og for sølvtorsk var prosentandelen 1,8% lavere i ERS sammenlignet med FDirs estimat.

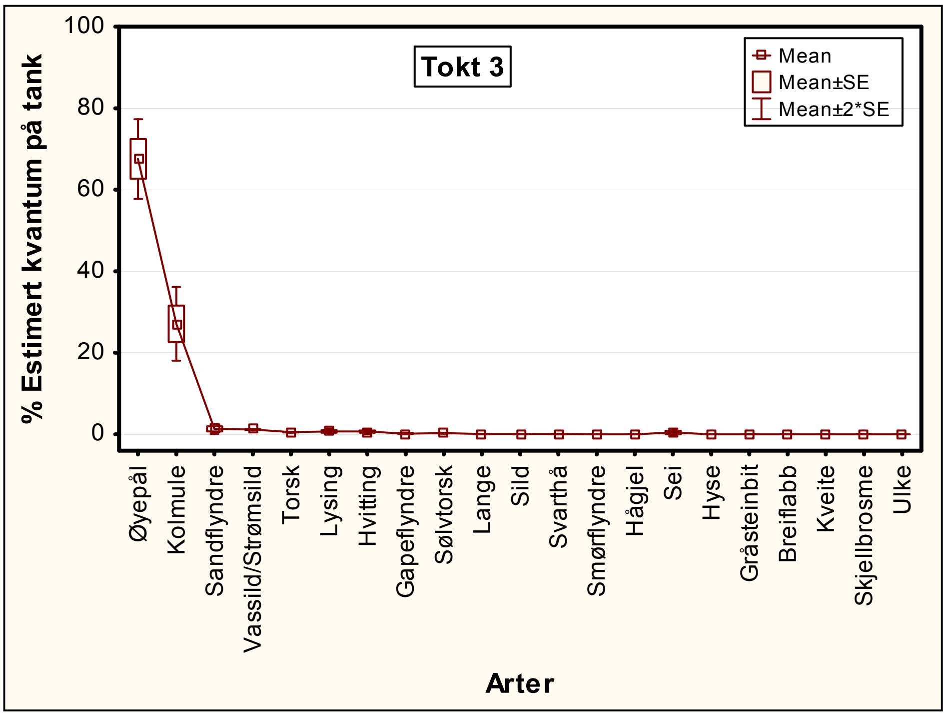
Det ble registrert hele 37 arter i FDirs målinger av artssammensetning på tank (se Tabell 3), og i ERS er det oppgitt bare 12 arter som har gått på tank.

FDirs estimat av øyepål på tank var mer enn 2 400 kg lavere enn det i ERS mens estimatet for øyepål var nesten 2 000 kg høyere enn det i ERS. Skipper på Tokt 2 benyttet seg aktivt av FDirs måleresultat av artssammensetning på tank før han gav opplysningene i ERS, men konsentrerte seg om de viktigste artene i fangstene. Imidlertid kritiserte skipper FDirs fremgangsmåte i prøvetakingen av artssammensetning, og i et brev som er sendt FDir hevdes det at med FDirs tallgrunnlag ville estimatet for lange bli hele 800 kg på tank bare i det første halet. FDirs estimat er på 753 kg lange på tank for hele turen (8 hal).

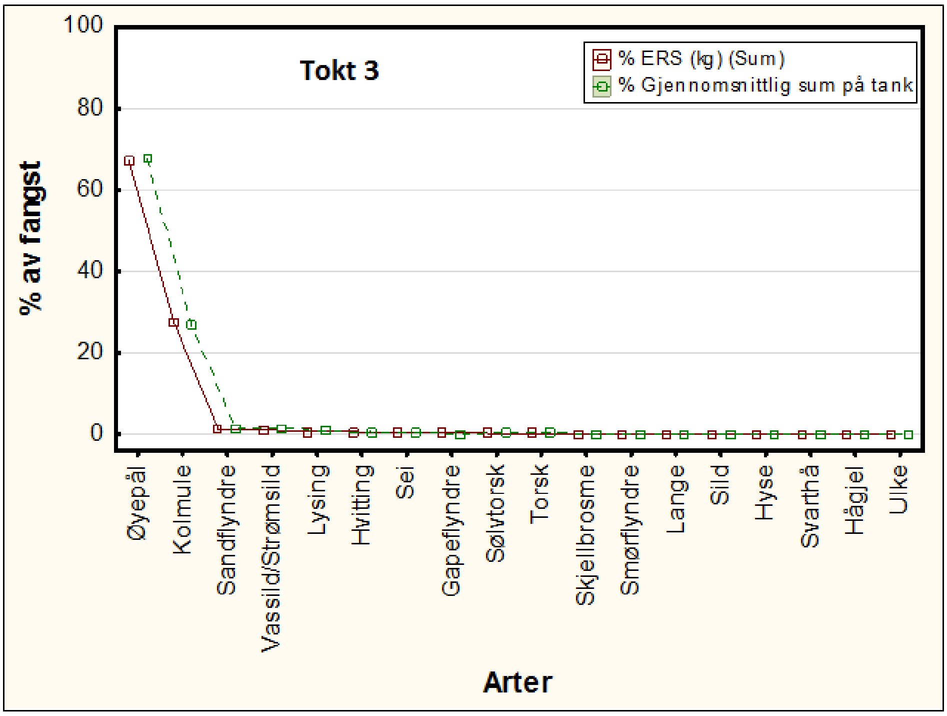
Tabell 3. Oppsummering av fangst på tank på Tokt 2 med artsfordeling i kvanta og prosent oppgitt i ERS og estimert gjennomsnitt i FDirs målinger basert på data fra 8 hal. Forskjellen i vekt per art på tank mellom FDirs estimat og ERS er gitt i den siste kolonnen i tabellen. Positive forskjeller indikerer et FDirs estimat er høyere enn de i ERS, og negative forskjeller indikerer at FDirs estimat er lavere enn de i ERS. * kvanta av konsumarter som antas å ha gått på tank.

Arter	**ERS (kg)**	**ERS (%)**	**Estimert på tank (kg)**	**Estimert på tank (%)**	**Forskjell (kg)**
Kolmule	48 700	45,39	48 225	44,94	-475
Øyepål	38 900	36,25	36 452	33,97	-2 448
Strømsild	6 800	6,34	4 966	4,63	-1 834
Sølvtorsk	6 740	6,28	8 716	8,12	1 976
Svarthå	2 120	1,98	1 105	1,03	-1 015
Lysing*	1 850	1,72	2 286	2,13	436
Vassild	0	0,00	1 518	1,41	1 518
Gapeflyndre	780	0,73	1 284	1,20	504
Lange*	530	0,49	753	0,70	223
Smørflyndre*	400	0,37	377	0,35	-23
Hvitting	200	0,19	244	0,23	44
Sei*	170	0,16	259	0,24	89
Torsk*	110	0,10	272	0,25	162
Nordsjøsild	0	0,00	60	0,06	60
Hyse	0	0,00	94	0,09	94
Lomre	0	0,00	124	0,12	124
Skjellbrosme	0	0,00	243	0,23	243
Sjøpølse	0	0,00	93	0,09	93
Sjøkreps	0	0,00	80	0,07	80
Havmus	0	0,00	33	0,03	33
Asymmetrisk kråkebolle	0	0,00	16	0,01	16
Tverrhalet langebarn	0	0,00	2	<0,01	2
Hågjel	0	0,00	36	0,03	36
Isgalt	0	0,00	10	0,01	10
Blekksprut	0	0,00	4	<0,01	4
Piggskate	0	0,00	17	0,02	17
Reke	0	0,00	5	<0,01	5
Snegl	0	0,00	5	<0,01	5
Sjøanemone	0	0,00	2	<0,01	2
Firetrådet tangbrosme	0	0,00	0,3	<0,01	0,3
Trollhummer	0	0,00	0,2	<0,01	0,2
Børstemakk	0	0,00	0,1	<0,01	0,1
Sypike	0	0,00	9	0,01	9
Panserulke	0	0,00	2	<0,01	2
Eremittkreps	0	0,00	8	0,01	8
Langhalet langebarn	0	0,00	1	<0,01	1
Laksesild	0	0,00	0,5	<0,01	0,5
Alle	**107 300**	**100,00**	**107 300**	**100,00**	**0**

A.



B.



Figur 3. A. Gjennomsnittlig prosentandel med 1*standardfeil (SE) og 2*SE av arter registrert i fangsten som gikk på tank på Tokt 3. Toktet ble gjennomført på Egersundbanken (10 hal ble undersøkt) i perioden 6.-10. september 2014. B. Sammenligning av gjennomsnittlig prosentandel av arter i fangsten som gikk på tank estimert ut fra FDirs målinger av artssammensetning og prosentandel av arter tatt fra ERS på Tokt 3.

Øyepål og kolmule var de klart viktigste artene i fangsten på Tokt 3, og det ble kalkulert gjennomsnittlige prosentandeler av øyepål og kolmule på henholdsvis 67,5% og 27,1% i fangsten som gikk på tank (Figur 3A). Summen av sei, torsk og hyse som gikk på tank var 0,9%. Prosentandelen av nordsjøsild på tank var svært lav (0,03%).

Det var svært god overensstemmelse i prosentandeler av ulike arter på tank mellom FDirs estimat og de gitt i ERS (Figur 3B).

Det ble registrert 18 arter i FDirs målinger av artssammensetning på tank (se Tabell 4), og det samme antall arter ble gitt i ERS.

Skipper på Tokt 3 benyttet seg svært aktivt av FDirs måleresultat av artssammensetning på tank før han gav opplysningene i ERS, og han passet på at alle artene registrert av FDir var med i ERS.

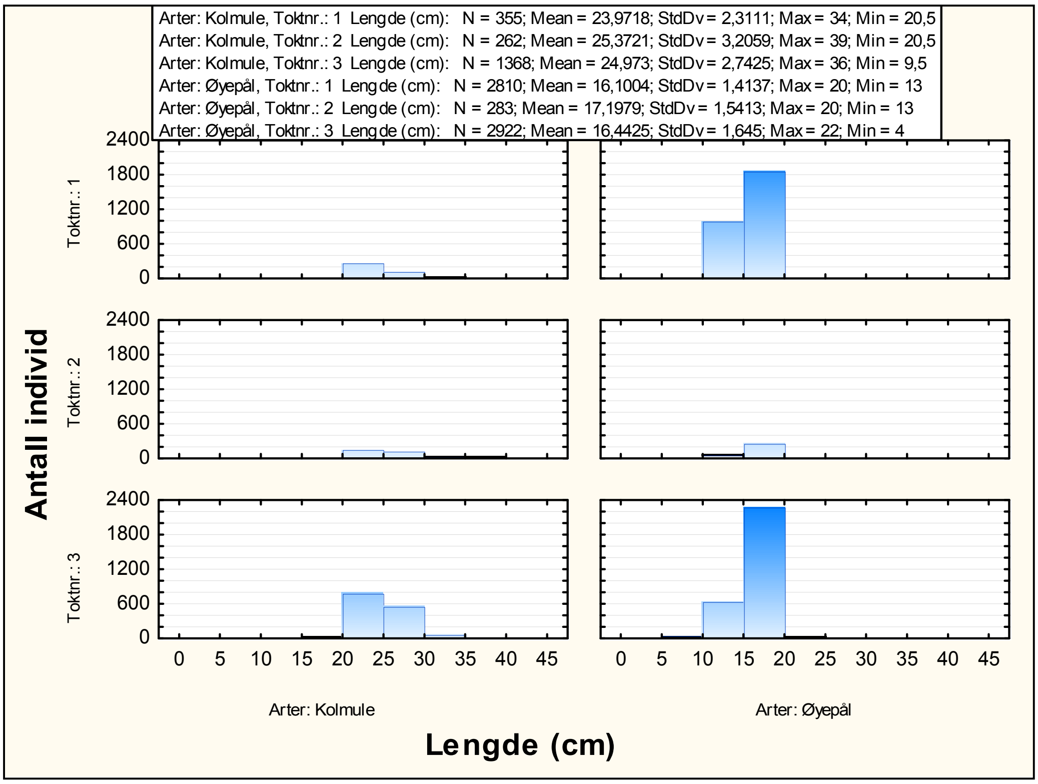
Tabell 4. Oppsummering av fangst på tank på Tokt 3 med artssammensetning i kvanta og prosent oppgitt i ERS og estimert gjennomsnitt i FDirs målinger basert på data fra 10 hal. Forskjellen i vekt per art på tank mellom FDirs estimat og ERS er gitt i den siste kolonnen i tabellen. Positive forskjeller indikerer et FDirs estimat er høyere enn de i ERS, og negative forskjeller indikerer at FDirs estimat er lavere enn de i ERS. * = Kvanta av konsumarter som antas å ha gått på tank.

Arter	**ERS (kg)**	**ERS (%)**	**Estimert på tank (kg)**	**Estimert på tank (%)**	**Forskjell (kg)**
Øyepål	101 541	67,21	102 039	67,54	498
Kolmule	41 706	27,60	40 919	27,08	-787
Sandflyndre	1 807	1,20	1 992	1,32	185
Strømsild	1 745	1,16	1 778	1,18	33
Lysing*	1 002	0,66	1 065	0,71	63
Hvitting	965	0,64	1 009	0,67	44
Sei*	742	0,49	650	0,43	-93
Gapeflyndre	470	0,31	272	0,18	-198
Sølvtorsk	435	0,29	425	0,28	-10
Torsk*	363	0,24	758	0,50	395
Skjellbrosme	82	0,05	21	0,01	-61
Smørflyndre*	70	0,05	12	0,01	-58
Lange*	46	0,03	45	0,03	-1
Nordsjøsild	42	0,03	43	0,03	1
Hyse	36	0,02	6	<0,01	-30
Svarthå	27	0,02	37	0,02	10
Hågjel	2	<0,01	9	0,01	7
Ulke upes.	1	<0,01	2	<0,01	1
Alle	**151 082**	**100,00**	**151 082**	**100,00**	**0**

På Tokt 2 og 3 ble det også registrert betydelige mengder av sjøkreps i noen av trålhalene. Sjøkrepsen ble sortert ut samtidig med utsorteringen av konsumfisk, og ble oppbevart i rekekorger. Den ble kokt og spist av mannskapet om bord etter hvert som den ble fanget.

Sjøkrepsen ble ikke oppgitt i ERS, men det kan dreid seg om 150-200 kg totalt på hvert av de to toktene.

Lengdefordeling av fiskearter



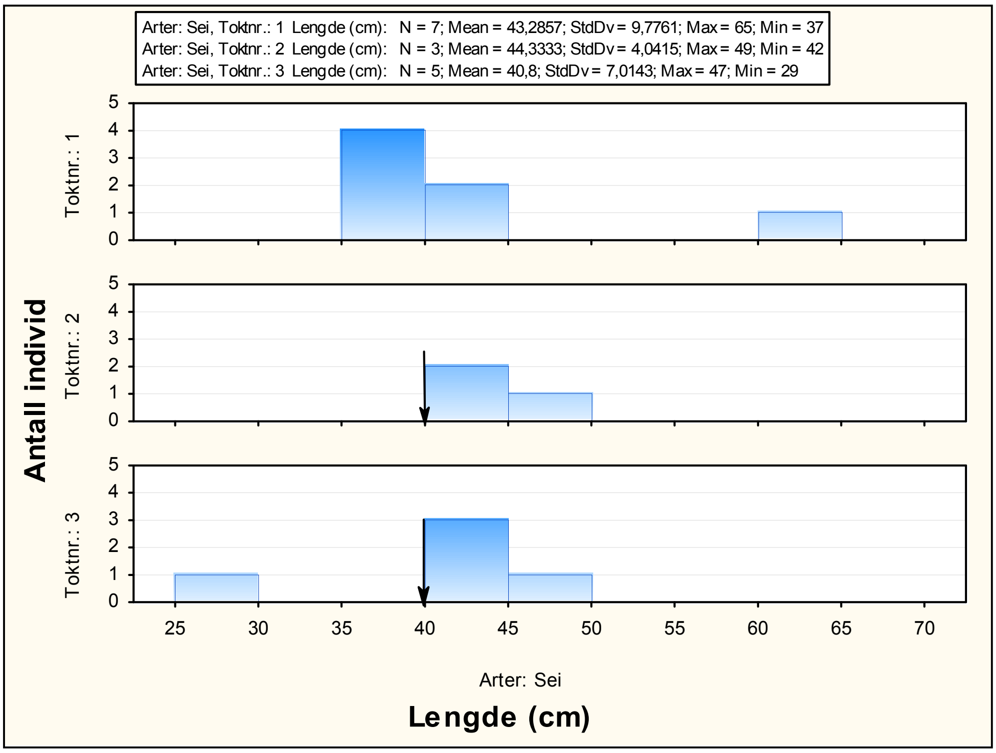
Figur 4. Lengdefordeling av målartene kolmule og øyepål per tokt (Tokt 1-3). Gjennomsnittlig lengde (cm) med tilhørende standardavvik og minimums- og maksimumslengder for hver av artene per tokt er oppgitt.

Det ble lengdemålt 1 995 stk. kolmule og 6 015 stk. øyepål til sammen på de tre toktene. Den gjennomsnittlige lengden av kolmule var mellom 24,0 cm og 25,4 cm på de tre toktene med minimums- og maksimumslengder på henholdsvis 9,5 cm og 39,0 cm (Figur 4). For øyepål lå gjennomsnittslengden mellom 16,1 cm og 17,2 cm med minimums- og maksimumslengder på henholdsvis 4,0 cm og 22,0 cm.

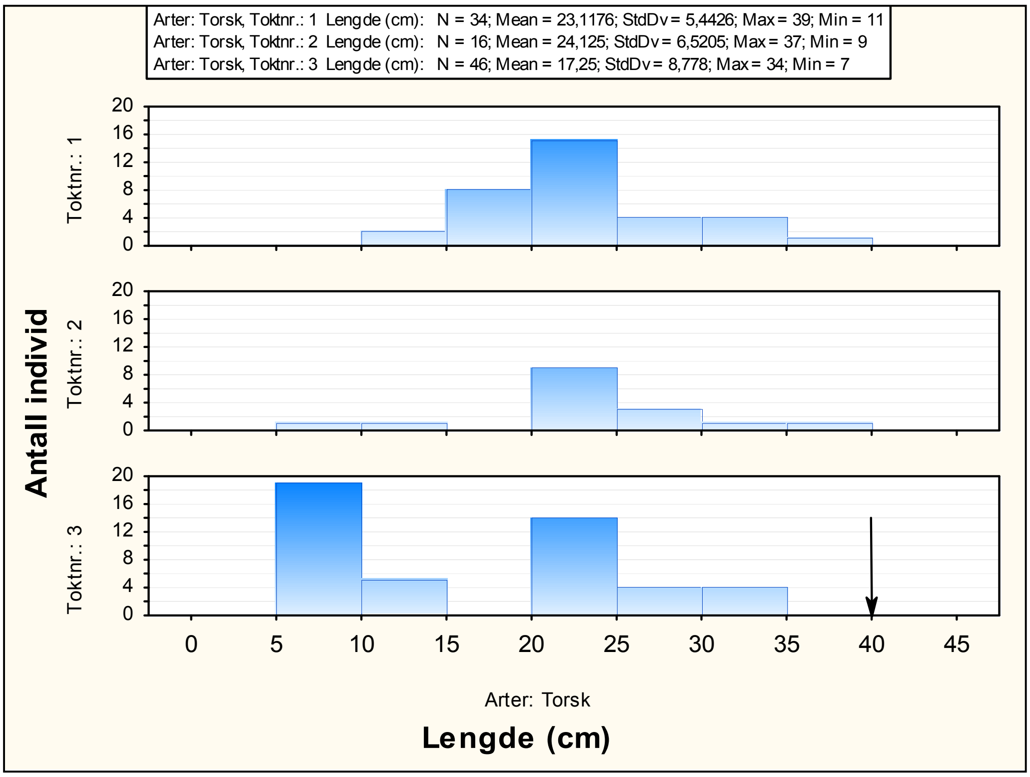
Det ble registrert lengdemålt 15 stk. sei totalt i FDirs prøver på de tre toktene, og den gjennomsnittlige lengden av sei som gikk på tank var mellom 40,8 cm og 44,3 cm (Figur 5). Minimumslengden varierte fra 29 cm til 42 cm mellom toktene, og maksimumslengden lå mellom 47 cm og 65 cm. Hovedtyngden av sei i prøvene var større enn minstemålet på 40 cm.

Det ble funnet i alt 96 stk. torsk i prøvene tatt i løpet av de tre toktene. Gjennomsnittslengden av torsk som gikk på tank lå mellom 17,3 cm og 24,1 cm (Figur 6). Minimums- og maksimumslengden lå henholdsvis fra 7,0 cm til 11,0 cm og fra 34,0 cm til

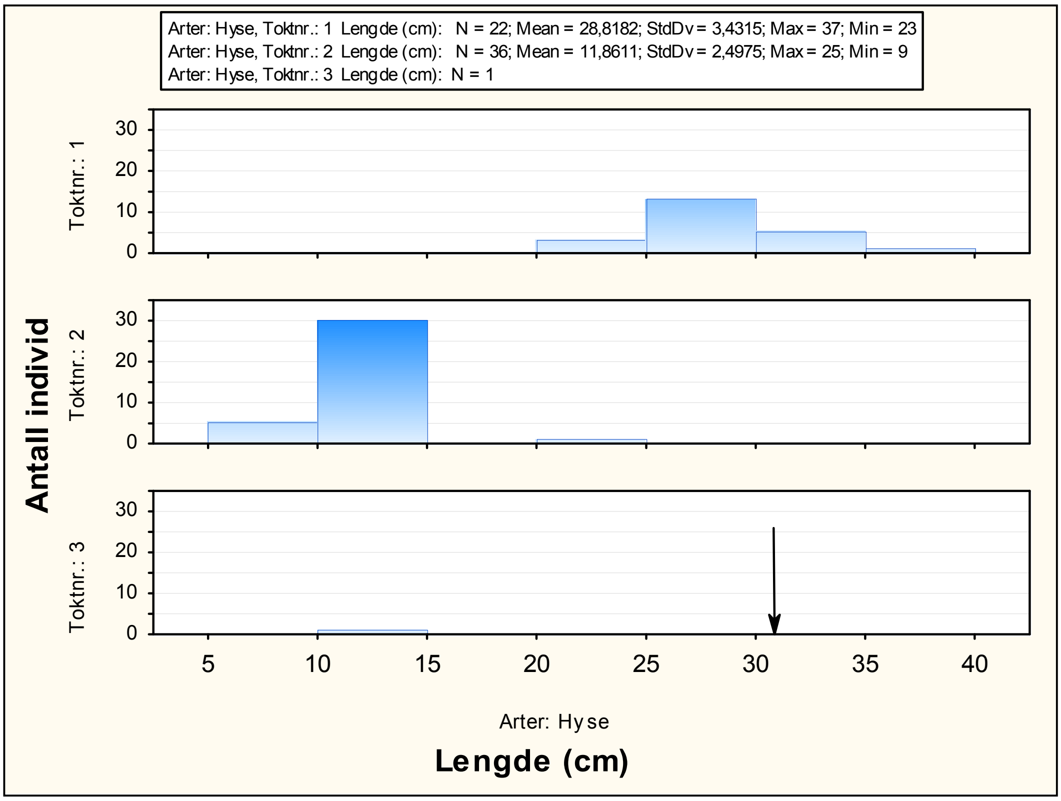
39,0 cm mellom toktene. All torsk som ble registrert i FDirs prøver var altså mindre enn minstemålet på 40,0 cm.



Figur 5. Lengdefordeling av sei per tokt (Tokt 1-3). Gjennomsnittlig lengde (cm) med tilhørende standardavvik og minimums- og maksimumslengder per tokt er oppgitt. Pilene i figuren angir minstemålet på 40,0 cm.

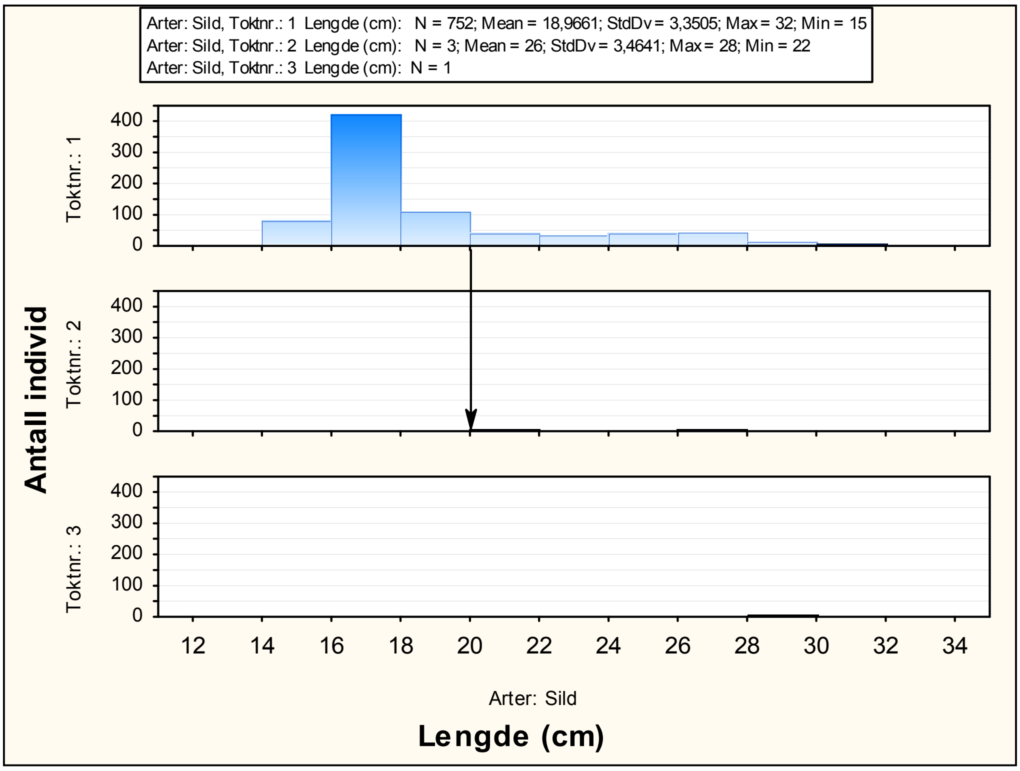


Figur 6. Lengdefordeling av torsk per tokt (Tokt 1-3). Gjennomsnittlig lengde (cm) med tilhørende standardavvik og minimums- og maksimumslengder per tokt er oppgitt. Pilen i figuren angir minstemålet på 40,0 cm.



Figur 7. Lengdefordeling av hyse per tokt (Tokt 1-3). Gjennomsnittlig lengde (cm) med tilhørende standardavvik og minimums- og maksimumslengder per tokt er oppgitt. Pilen i figuren angir minstemålet på 31,0 cm.

Det ble registrert til sammen 59 stk. hyse i prøvene tatt i løpet av de tre toktene. Gjennomsnittslengden av hyse som gikk på tank var 28,8 cm på Tokt 1 og 11,9 cm på Tokt 2 (Figur 7). Minimums- og maksimumslengden på Tokt 1 var henholdsvis 23,0 cm og 37,0 cm, og på Tokt 2 var minimums- og maksimumslengden henholdsvis 9,0 cm og 25,0 cm. På Tokt 3 ble det funnet 1 stk. hyse i lengdeintervallet 10-15 cm. På Tokt 1 ble det altså registrert noen individ av hyse i prøvene som var større enn minstemålet på 31,0 cm mens all hyse i prøvene på Tokt 2 og 3 var mindre enn minstemålet.



Figur 8. Lengdefordeling av nordsjøsild per tokt (Tokt 1-3). Gjennomsnittlig lengde (cm) med tilhørende standardavvik og minimums- og maksimumslengder per tokt er oppgitt. Pilen i figuren angir minstemålet på 20,0 cm.

Det ble lengdemålt til sammen 756 stk. nordsjøsild fra prøvene tatt i løpet av de tre toktene, men det var kun på Tokt 1 (752 individ ble lengdemålt) at denne arten var tallrik i FDirs prøver. Hovedtyngden av nordsjøsild som ble registrert på Tokt 1 var altså yngel, og den gjennomsnittlige lengden var 19,0 cm (Figur 8). Lengden varierte mellom 15,0 cm og 32,0 cm på dette toktet. På Tokt 2 og Tokt 3 ble det bare funnet 4 stk. nordsjøsild totalt i prøvene med en lengde fra 22,0 cm til 29,0 cm.

Konklusjoner

FDir registrerte omtrent tre ganger så mange arter i fangsten som gikk på tank enn de som ble oppgitt i ERS på Tokt 2. På Tokt 1 og 3 var det bra samsvar mellom antall arter i FDirs prøver og de som er gitt i ERS.

På Tokt 1 var det stor forskjell mellom FDirs estimerte gjennomsnittskvantum på tank av øyepål og nordsjøsild sammenlignet med kvantaene gitt i ERS, til tross for at skipper hadde tilgang til resultatene av målingene. FDirs estimat av øyepål på tank var mer enn 28 000 kg lavere enn det i ERS mens estimatet for nordsjøsild var mer enn 11 000 kg høyere enn det i ERS.

Mengden av sei, torsk og hyse som gikk på tank var ≤ 1,4% av totalfangsten på alle toktene. Mengden av nordsjøsild på tank ble estimert til 8,9% av totalfangsten på Tokt 1. På de andre toktene utgjorde nordsjøsild < 0,1% av totalfangsten på tank.

Den gjennomsnittlige lengden av kolmule var mellom 24,0 cm og 25,4 cm på de tre toktene med minimums- og maksimumslengder på henholdsvis 9,5 cm og 39,0 cm. For øyepål lå gjennomsnittslengden mellom 16,1 cm og 17,2 cm med minimums- og maksimumslengder på henholdsvis 4,0 cm og 22,0 cm.

Hovedtyngden av sei i FDirs prøver var større enn minstemålet på 40 cm. All torsk i prøvene var mindre enn minstemålet på 40 cm, og hyse i prøvene var mindre enn minstemålet på 31 cm på Tokt 2 og 3 og var rundt minstemålet på Tokt 1. Det ble lengdemålt i alt 752 stk. nordsjøsild på Tokt 1, og hovedtyngden av denne silden var mindre enn minstemålet på 20 cm (gjennomsnittlig lengde: 19,0 cm). Lengden av silden varierte mellom 15,0 og 32,0 cm på dette toktet.

Basert på resultatene av FDirs målinger av artssammensetning er det åpenbart at skipper, ut i fra øyemål, ikke er i stand til å angi alle artene i fangsten. Det betyr at arter som opptrer i små kvanta i fangsten ikke blir gitt i ERS, og dette har betydning for biodiversitetsaspektet og økosystembetraktninger. Det er også åpenbart at skipper ikke er i stand til å angi en korrekt artssammensetning i fangsten for hvert hal ut i fra øyemål. Ved landing av industrifangst uten kontroll er det artssammensetningen i ERS som er basis for føring av artssammensetningen på sluttseddel. Det medfører at FDirs fangststatistikk også blir feil. Hvis man skal oppnå en mest mulig korrekt fangststatistikk for industrifisket, må man enten ha pålagt prøvetaking om bord på fartøyene eller ved landing. Hvis ikke, er det nødvendig å videreføre ordningen med bifangstavsetning i industrifisket.

Da det ble registrert relativt store mengder med yngel av nordsjøsild i fangstene tatt på Egersundbanken på Tokt 1, bør det vurderes om dette området bør stenges midlertidig for fiske med småmasket trål ved stort innslag av sildeyngel i fangstene.

Check of age readings of Norway pout in the North Sea between Denmark and Norway

By Julie Olivia Davies, J. Rasmus Nielsen and Lotte Worsøe Clausen,

Technical University of Denmark, National Institute of Aquatic Resources, DTU Aqua.

1. Introduction, background, and purpose

This working document presents a preliminary age reading check conducted in 2016 of otoliths from Norway pout in the North Sea made between Danish and Norwegian age readers at DTU Aqua (DK) and IMR (N). In order to provide some information on the quality of the Norway pout age readings a preliminary check was initiated in order to investigate whether there are any age reading issues between the countries reading otoliths of Norway pout caught in the commercial Norway pout fishery in the North Sea and Skagerrak-Kattegat areas (nop34 ICES Area IV and IIIa stock). Age readings from the Danish and Norwegian commercial fishery are directly used in the Norway pout stock assessment to estimate catch, mean weight, maturity and mortality at age. Also, the age readings from the IBTS survey in first and third quarter of the year are used in several stock assessment tuning fleets to obtain catch per unit of effort (CPUE) indices by age in several assessment tuning time series. The age determination of otoliths from the IBTS surveys involves additional institutes.

The results from the age reading check are directly relevant for the ICES benchmark assessment for the Norway pout stock conducted in August 2016, ICES WKPOUT. However, as a full scale exchange is already planned under the remits of ICES WGBIOP and results should be available by September 2017 these preliminary results are only to indicate that there are discrepancies in the age estimations provided by the participating laboratories.

The working document is subdivided into 3 main sections with introduction, initial otolith check material, indicative results and time plan for the current full scale otolith exchange program.

1. Introduction with background and purpose
2. Initial otolith check material and indicative results
3. Future full scale otolith exchange program

2. Initial otolith check material and indicative results

During 2015-2016, a small scale otolith exchange check for Norway pout in the North Sea was arranged between Denmark and Norway (DTU Aqua Denmark and IMR Norway). Denmark and Norway are the only nations having targeted Norway pout commercial fishery with small meshed trawls for reduction purposes in the North Sea and Skagerrak. The Danish Norway pout commercial fishery is at present mainly conducted in the Northern North Sea at Fladen Ground, and the Norwegian commercial Norway pout fishery is mainly conducted in the Norwegian zone (EEZ) in the North Sea. Only a limited fishery is conducted in Skagerrak.

Accordingly, there were 127 otoliths selected from the Danish commercial fishery and 100 otoliths from the Norwegian commercial fishery to be checked. The selected otoliths covered the fishery in the respective main fishing areas in the autumn 2014 (and additionally a few otoliths from spring 2015). Furthermore, the otoliths covered the full individual fish length range of Norway pout observed in the North Sea fishery and surveys during that period, i.e. covered a very broad length and age range in both samples.

The otoliths were first read by the sampling institute. They were then sent to the sister institute with only indication of fish number, length and date of capture for a cross age reading check at the other institute. Consequently, the age reading of the other party was not known to the age reader when reading the otoliths from the other institute. After the cross check age reading period ended in spring 2016, the otoliths and age readings were compiled for initial analyses.

Below are the results of these initial analyses presented.

Sample Overview

	Area	Quarter	Year	Length range	No. of fish
Denmark	4A/45FO	4	2014	9-18 cm	40
	4A/45FO	4	2014	9-18.5 cm	44
	4A/49FO	4	2014	8.5-17.5 cm	43
Norway	4A/42-05	3	2015	15-20 cm	14
	4A/42-23	4	2014	13.5-18 cm	50
	4A/42-23	4	2014	9-15.5 cm	36

Results

a) Danish samples
The readers agreed on 77% of the samples, with 100% agreement at age 0 and a decrease in agreement with an increase in age. The table below shows the reader comparison matrix; both countries agree that there are 46 fish which are age 0, 46 fish which are aged 1 and 6 fish which are age 2. Where there is disagreement, there is a tendency for Norway to estimate the ages of the fish to be one year older in comparison to Denmark. This is indicated by the red boxes where Norway has estimated one fish to be 1 year old in comparison to an age of 0 estimated by the Danish reader. In addition, Norway has estimated 28 fish to be age 2 where Denmark has estimated age 1.

	Age DK		
Age N	0	1	2
0	46		
1	1	46	
2		28	6

b) Norwegian samples
The readers agreed on 65% of the samples, with 100% agreement at age 0 and a decrease in agreement with an increase in age. A similar pattern in seen where Norway will estimate the fish to be older in comparison to Denmark, see the table below. Both countries agree that there are 19 fish which are 0 years old, 40 aged 1 and 6 aged 2. The values in red indicated where Norway has

estimated 22 fish to be aged 2 when Denmark has estimated them to be 1, 5 fish have been assigned an age of 3 and 8 an age of 4 when Denmark ages these fish to be just 2 years old.

The lower level of agreement in the Norwegian sample set coincides with a broader length distribution with fish 18-20cm included in the exchange set.

	Age DK		
Age N	0	1	2
0	19		
1		40	
2		22	6
3			5
4			8

It appears that especially for the larger fish there are discrepancies in the otolith readings and ageing of the Norway pout. As the exchange was carried out without the inclusion of otolith images for the readers to record their otolith interpretations on it is difficult to identify where the discrepancies in the age determinations are. However, as Norway pout grow very quickly in the first year the centre of the otoliths are highly opaque which may cause problems when identifying the first winter ring. In addition, the subsequent growth zones are much narrower in comparison and it is likely that the interpretation of these narrow growth zones at the edge may also contribute to the differences in the ages estimated by the two countries, especially in respect to the older fish.

The results from the pre-calibration exercise between Denmark and Norway clearly show discrepancies between the readers involved; the overall agreement of 72% is below 80% and thus there is a need to carry out a full scale otolith exchange where images are provided for the readers to annotate.

3. Future full scale otolith exchange program

Based on the above results it seems necessary - and it is recommended - that the planned full scale otolith exchange program is carried out as soon as possible for the Norway pout stock in the North Sea and Skagerrak-Kattegat.

A full scale exchange and calibration workshop is currently underway, according to WGBIOP standards and will include all relevant laboratories supplying age-data to ICES on the Norway pout.

The recommended plan for such a full scale otolith exchange program is the following:

- Photographing the material for exchange: Jul-Sep 2016;
- Exchange of otoliths and cross reading: Sep-Dec 2016;
- Analysis of exchange otolith readings and results by the exchange coordinator and selected colleagues: Jan-Mar 2017;
- Results and potential correction of data in relation to assessment (catch at age, tuning and survey fleets, etc.): Apr-Jul 2017;
- Implementation in the Norway pout assessment or potential InterBenchmark Assessment: Aug-Sep 2017.

Working document for WKPOUT 2016

Estimation of abundance of Norway pout from shrimp surveys using the new open source software StoX

Espen Johnsen and Guldborg Søvik

Introduction

Annual shrimp swept-area surveys have been conducted by the Institute of Marine Research since 1984 in Skagerrak and the Norwegian Deep in the eastern side of the Norwegian trench in the North Sea. The main objective of the survey is to monitor abundance and distribution of the northern shrimp (*Pandalus borealis*) stock. In addition to northern shrimp, the catch of fish, Norway lobster and sea cucumber have been sorted to species where the total weight and abundance, the individual length and/or weight have been recorded for each species. The depth (100-550 m) and geographical distribution of the trawl positions of the shrimp survey does not overlap with the positions covered by the International Bottom Trawl Surveys organized by ICES, however, Norway pout is a very common species in the catches for both the IBTS surveys and the Norwegian trawl survey despite the non-overlapping survey areas, and the purpose of the work is to analyze the shrimp survey data with the purpose of establishing an additional fishery-independent survey time series that may be used as a future input in the stock assessment of Norway pout in the Skagerrak and North Sea.

Method

In 2006, the survey period was moved from May/June to January/February in order to provide better biomass estimates of 1-group shrimp (recruitment) and berried females (SSB). In 2013, the list of the sampling stations was revised, and from 2014 104 stations with fixed positions is in the fixed station list.

The trawling is carried out with a Campelen research trawl with a Rockhopper ground gear made of rubber discs (see Engås and Godø 1989). The 20 mesh size in the fishing bag with a 6 mm inner net in the cod end. Waco 1500 kg trawl doors is used. To stabilize the doors distance, a 10 meter long strapping rope (Engås and Ona, 1993) mounted 200 meter in front of the trawling doors was implemented as standard in 2009. The distance between the doors is typically 46-48 meter. To measure the performance of the trawling, depth sensors, trawl eye and door distance sensors are used as standard. Bottom temperature and salinity were measured by CTD at each trawl station.

Standard towing time is 30 minutes with a towing speed of 3 knots over ground. In areas with expected high rates of fish the towing time may be reduced to 15 minutes to avoid large catches.

In this analyses, only survey data for the period 2010-2016 was available, however, the full time series will be available by the end of 2016 which enables a full time series analyses.

Survey area and strata

Figure 1 shows the area survey area, strata boarders and fixed station positions. In our swept-area calculations, the strata have been modified by merging some of the previous strata, and new strata boarders are depicted in Figure 2. The new strata is the same as used for the updated survey time series estimated for Northern shrimp.

Estimating catch rates of Norway pout

No age reading of Norway pout is available for shrimp survey, and all swept-area estimates are given as number by cm groups. The software StoX (http://www.imr.no/forskning/prosjekter/stox/nb-no) for the swept-area estimates. Density of Norway pout by trawl station (*i*) by cm length group (l) is calculated as:

$$\rho_{l,i} = \frac{x_{l,i}}{a_i}$$

where the number of individuals (x) by length group is divided by the area swept (*a*). Area swept is calculated as towing distance multiplied trawling width (11.7 m), which is the same as used for the Northern shrimp estimates. The mean density by length group by stratum is estimated as:

$$\bar{\rho}_l = \frac{1}{n}\sum_{i=1}^{n} p_{l,i}$$

Where n is number of station in a stratum. The stratified mean number for the entire survey area is estimated as:

$$N_l = A\sum_{k=1}^{nk} \bar{\rho}_l\, W$$

Where nk is number of strata and W is the proportion of the total survey area (A) in stratum *k.*

Validation of results

The conversion from abundance by length groups to abundance by age is feasible using an age length key. In this work, a constant age length key to estimate Numbers of age 1 for all 7 years was used (Table 1). It is possible for future work to utilize the age readings from the IBTS Q1 survey, and for future surveys we may start to read otoliths for Norway pout.

Results and discussion

Norway pout was caught in about 99% of all trawl stations, where the highest catch rates where shallower than 350 meter (Figure 3). Figure 4 shows the estimated number of Norway pout by length group by survey for 2010 to 2016. Although, the survey effort has not been constant between all years as bad weather and time constraints has made it impossible to cover all stations, the estimates seem to reflect the stock size. To test the reliability of the survey, the estimated abundance of age 1 individuals (Figure 5) was compared with the with the IBTS Q1 abundance index for age 1 (Figure 5).

The Pearson's product-moment correlation between log(abundance of IBTS Q1 age 1) and log(abundance age 1 from shrimp survey) was high 0.87 ($p = 0.02$). As we didn't have 2016 data available for IBTS Q1 2016, only data for 2010 to 2015 was used in this analysis. This high correlation indicates that the population of Norway pout in the shrimp survey area has a similar recruitment dynamic as in the shallower parts of the North Sea. More advanced age length key is needed to test the internal consistency and the external consistency of older Norway pout.

Summary

The objective of this work was to carry out a preliminary analyses of the Norway pout data recorded during the shrimp survey to examine the usefulness of the Shrimp survey in the Norway pout stock assessment. Despite the shortcomings in the analyses caused by the lack of age reading and short time series, the results clearly indicates that the survey estimates are in line with the IBTS survey time series. Therefore, the full survey time series (from 1984) should be estimated when data are available, and more advanced methods to estimate age based from the length distributions before the survey time series should be tested as an input to the Norway pout stock assessment.

References

Engås, Arill, and Olav Rune Godø. "Escape of fish under the fishing line of a Norwegian sampling trawl and its influence on survey results." *Journal du Conseil: ICES Journal of Marine Science* 45.3 (1989): 269-276.

Engås, A. and Ona, E. 1993. Experiences using the constraint technique on bottom trawl doors. ICES CM 1993/B:18, 10pp.

Tables

Table 1. Age length key used to estimate number of individuals of age 1 from the length distribution.

Length (cm)	Age 1	Age 2+
6	1	0
7	1	0
8	1	0
9	1	0
10	1	0
11	0.9	0.1
12	0.7	0.3
13	0.05	0.95
14 (and larger)	0	1

Figures

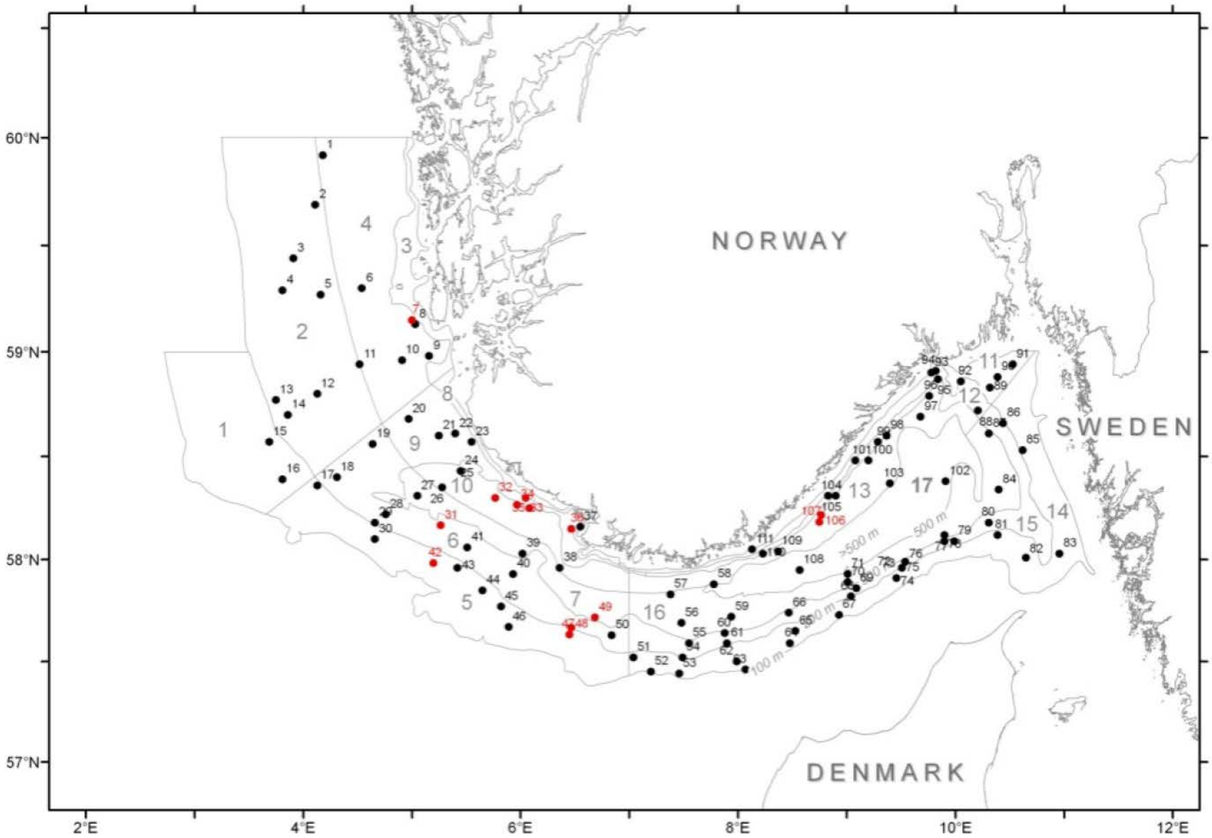
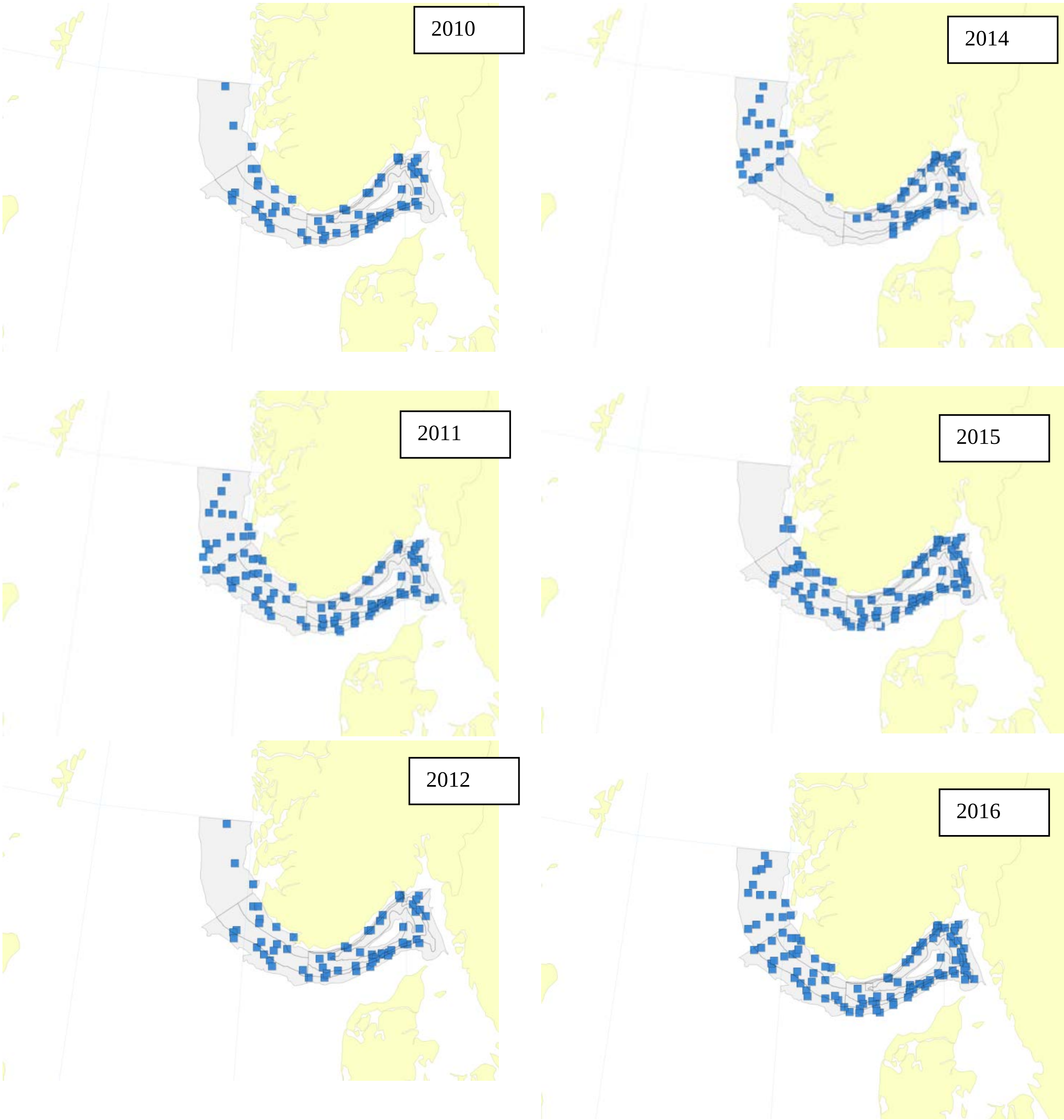


Fig. 1. Norwegian shrimp survey in Skagerrak and the Norwegian Deep (ICES Divs. IIIa and IVa east): the revised strata system (introduced in 2007 and adjusted in 2008) with the 111 fixed trawl stations. Trawl stations marked in red were introduced in 2008. (Taken from NAFO, ICES (2015) NAFO/ICES *Pandalus* Assessment Group Meeting, 9-16 September 2015. NAFO SCS Doc. 15/13. ICES CM 2015/ACOM:14, 85 s.)



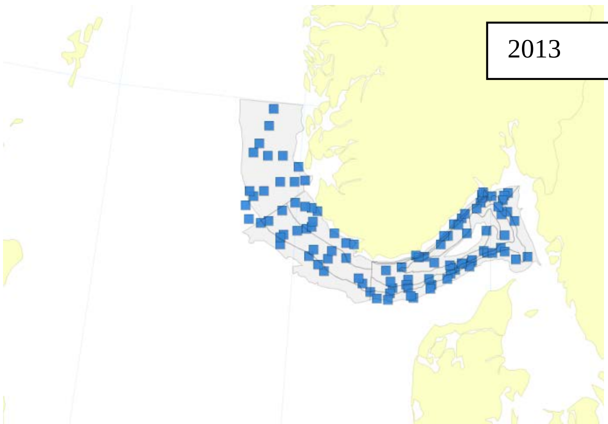


Figure 2. Survey area, strata and distribution of stations for the Norwegian shrimp survey. Blue squares shows stations with Norway pout in the catch, open squares depict stations with zero catch of Norway pout.

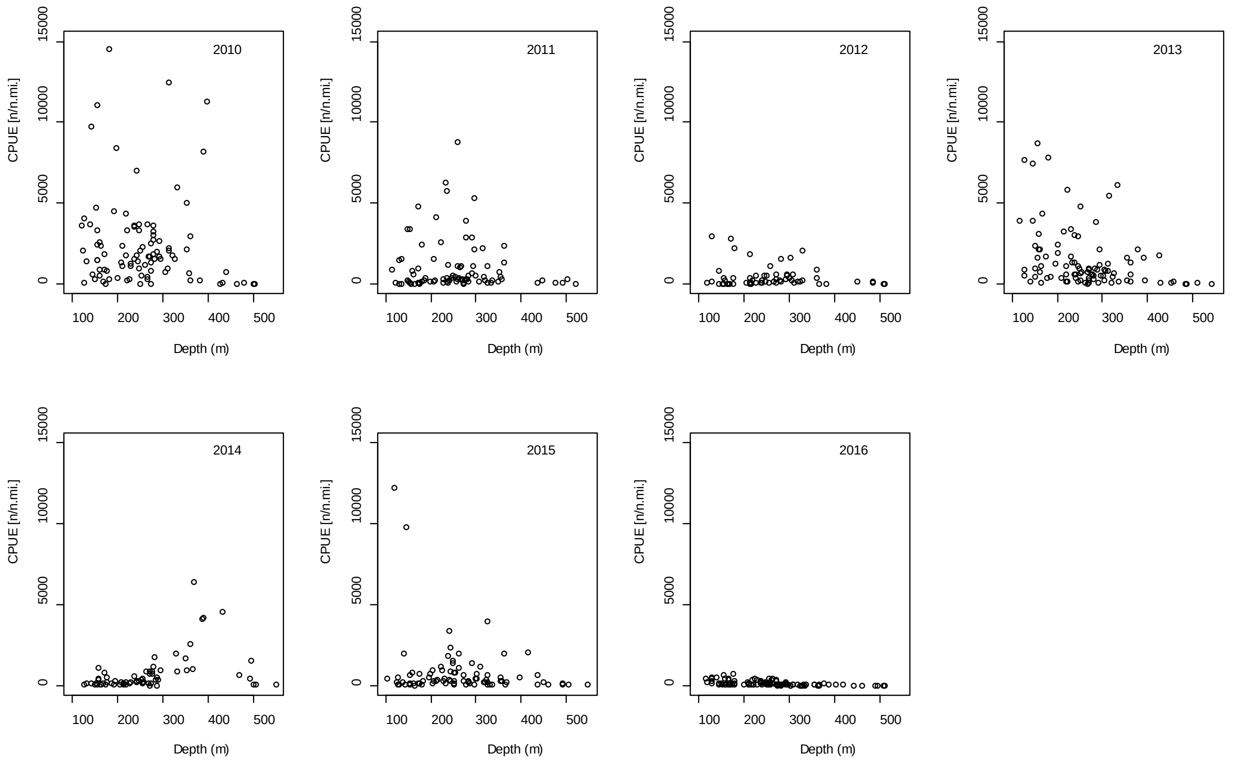


Figure 3. Depth vs. CPUE (n/towing distance) of Norway pout in the shrimp survey

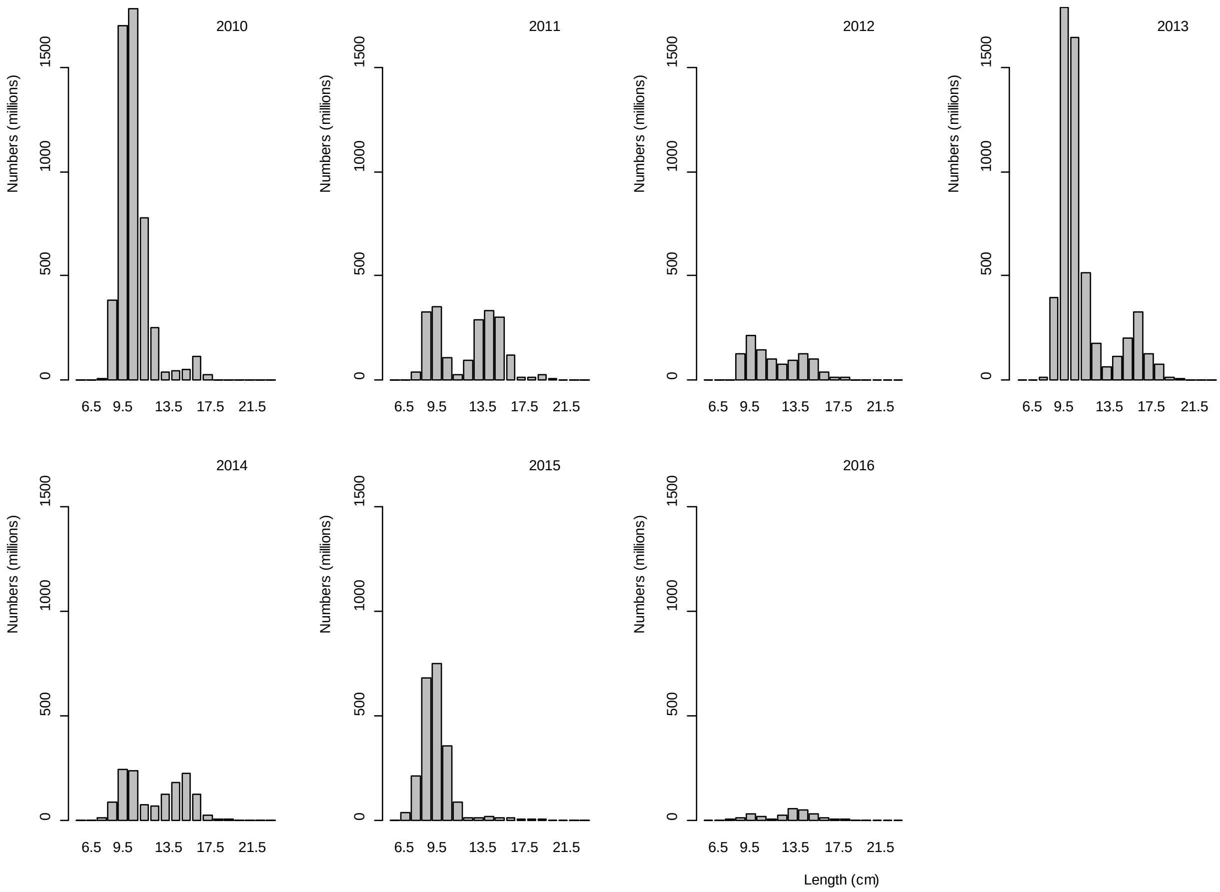


Figure 4. Estimated number of individuals by length of Norway pout by survey.

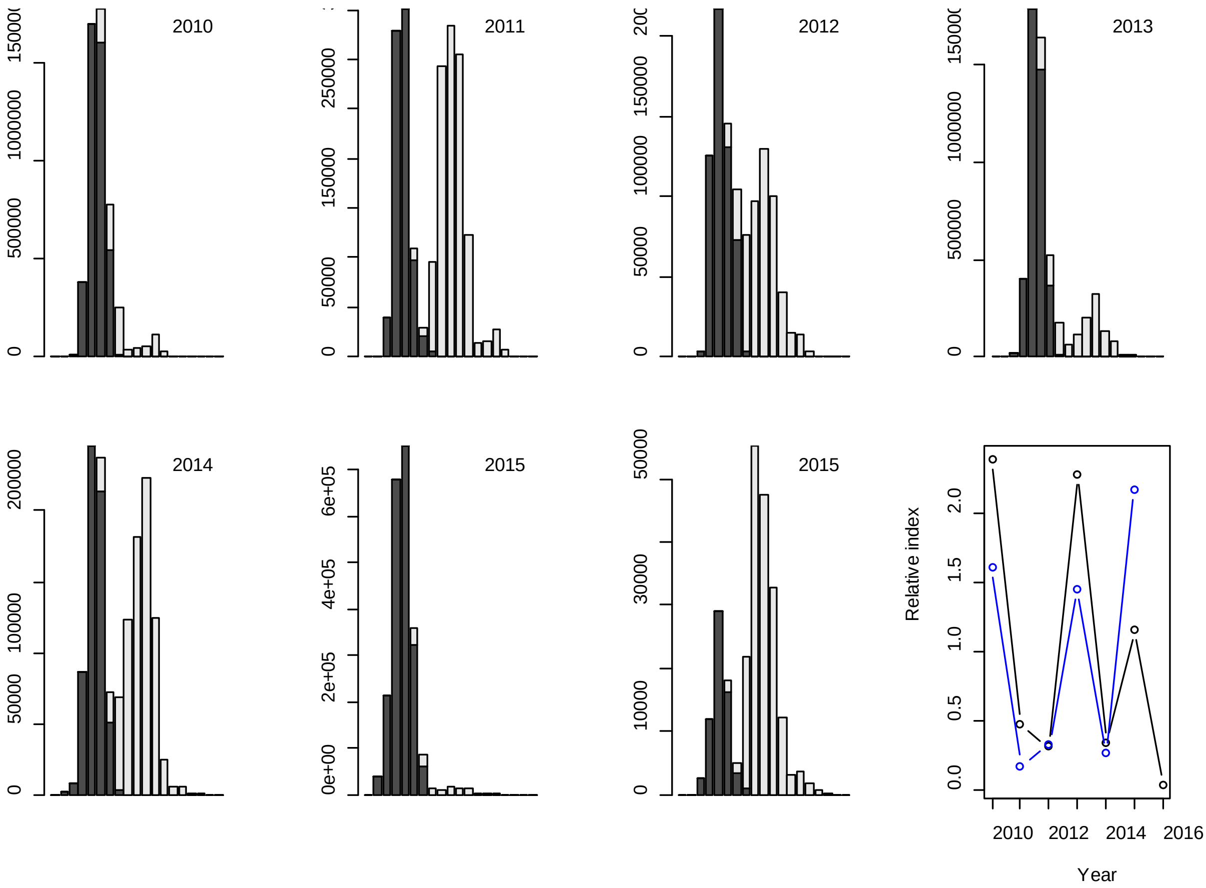


Figure 5. Estimated number of age 1 (black colums) by year derived by using the constant age length key presented in Table 1. Lower right figure; relative abundance indices of age 1 of Norway pout from the shrimp survey (black line) and IBTS Q1 (blue line).

SESAM - Seasonal State-space Assessment Model Applied to Norway Pout in the North Sea.

Anders Nielsen and Casper W. Berg

September 6, 2016

1 Introduction

Age based assessment models such as the SAM model (Nielsen and Berg, 2014) are typically formulated with time steps of one year. This is convenient because seasonal patterns can be ignored, but also because commercial catch data historically have been aggregated over years, which precludes analyzing them in finer time steps. However, when seasonal data are available the key stock assessment outputs (estimates of stock abundance, fishing mortality, and recruitment) can also be estimated on a seasonal basis, which enables quantification of the effects of seasonal management procedures that may optimize yield (Ferro et al., 2008) or reduce bycatch of certain species that are particularly vulnerable in certain periods of the year.

This document describes a seasonal extension of the SAM model (Nielsen and Berg, 2014) called SESAM. The model preserves the nice properties of the SAM model, namely that the fishing mortality is specified via an unobserved stochastic process that allows for gradual changes in both fishing pressure and selectivity, and catches are treated as observations with noise. This description is specific to the application of SESAM to Norway Pout in the North Sea.

2 Model

The yearly time step state-space assessment model (SAM) is defined in Nielsen and Berg (2014). The detailed formulas will not be repeated here, but in brief the model consist of two parts. 1) The logarithms of the age-specific stock sizes $\log N$ and the logarithms of the age-specific fishing mortality rates $\log F$ are considered to be a multidimensional unobserved stochastic process. 2) Conditional on the unobserved process the distributions of the observations of catches and survey indices are described. This two step approach allows for a flexible model with few model parameters, and allows assessments to be conducted with statistical rigor. Extending the SAM framework to use more flexible time steps is described here. For notational convenience we assume that each year is subdivided into a fixed number of equidistant intervals ($s = 1 \ldots S$). Although S can be any positive integer, in the following we will assume four seasons i.e. $S = 4$ and refer to the s subscript as quarter. We enumerate each observation from 1 to N (total number of observations) and map them to their corresponding time interval which we denote $t_1, t_2, \ldots, t_N$.

Fishing mortality In the standard yearly SAM the fishing mortality process is modelled as a multivariate random walk process, such that the vector $\log F_y$ is described by:

$$\log F_y = \log F_{y-1} + \epsilon_y$$

where the vector ϵ_y is assumed to follow a multivariate normal distribution with mean vector 0 and covariance matrix Σ_F.

In a seasonal model a seasonal pattern in the fishing mortality must be expected. A simple way to achieve this is to setup a separate process for each season in the model, such that e.g. first quarter fishing mortality in a given year only depends on first quarter fishing mortality in the previous year. This can be setup as a S-lagged process, such that:

$$\log F_{t_i} = \log F_{t_{i-S}} + \epsilon_i$$

here the vector ϵ_i is assumed to follow a multivariate normal distribution with mean vector 0 and covariance matrix Σ_F, which has the same AR(1) structure as in Nielsen and Berg (2014).

Future extensions of SESAM could include more general process formulations where the fishing mortality in a given season is allowed to depend on several previous lags, and where the covariance matrix is allowed to be differ between seasons.

A vague prior is imposed on $\log F \sim N(0, 20^2)$. This is merely to stabilize the likelihood optimization, and it was verified that this prior has practically no effect on the final estimates.

Stock size process The stock size process in the standard yearly SAM is defined to follow the yearly stock equation on logarithmic scale, such that $\log N_{a+1,y+1} \sim \mathcal{N}(\log N_{a,y} - (F_{a,y} + M_{a,y}), \sigma_a^2)$.

The extension to SESAM is to update the stock equation to seasonal time steps, and to scale the variance accordingly. The updated $\log N$ increment distribution becomes:

$$\log N_{a,t_i} \sim \begin{cases} \mathcal{N}\left(\log N_{a,t_{i-1}} - (F_{a,t_{i-1}} + M_{a,t_{i-1}})\Delta t_i,\ \sigma_a^2 \Delta t_i \right), & \text{if } t_i \text{ and } t_{i+1} \text{ are in same year} \\ \mathcal{N}\left(\log N_{a-1,t_{i-1}} - (F_{a-1,t_{i-1}} + M_{a-1,t_{i-1}})\Delta t_i,\ \sigma_a^2 \Delta t_i \right), & \text{otherwise} \end{cases}$$

Notice that the fish becomes one year older at January first.

Recruitment process The standard yearly SAM has different options for modelling the stock recruitment process, but the simplest option is a plain random walk on logarithmic initial stock sizes.

In SESAM recruitment could take place in one or more quarters – in the most general case in every quarter. For Norway Pout the zero year olds are never observed in the first two quarters, we therefore need only consider recruitment in the two last quarters of the year. To further simplify, we assume that all recruitment happens only in the third quarter, which permits a simple random walk assumption on the recruitment process in the third quarter only (lag of one year). While the latter assumption is unlikely to affect estimates of SSB and $\bar{F}$ given that these are mainly immature fish outside the selection range of the commercial gear, the estimated distribution of 0-year olds between quarter 3 and 4 and their corresponding fishing mortalities will be affected by this assumption.

Observations Standard catch- and survey-equations are used to predict the observations with a lognormal error term.

SESAM is implemented such that at the time steps can be set up to match the time steps of the observations exactly. E.g. it can potentially be set up to match a three week survey exactly. The fact that the internal time steps of the process matches the observations exactly makes it simpler to predict the observations without having to use interpolations. The only potential difficulty is when observations span more than one time step, but in such cases the prediction is simply adding predictions from each time step. E.g. if the model uses quarterly time steps (to match other data sources), but only yearly catch-at-age is observed, then the yearly catch at age is predicted as the sum of all four quarters.

For Norway Pout quarterly time steps are used and surveys are predicted deterministically from the start of the containing quarter to the center of the surveys observation interval.

Zero observations The assumption of having lognormal distributed observations does not permit observations equal to zero. In the standard SAM the number of age groups can typically be adjusted such that no more than a couple of percent of the data are zeroes. This means that zero observations may be treated as missing without introducing substantial bias. When catches are aggregated over quarters rather than years the probability of observing no catches increases, i.e. the proportion of zero observations gets larger, and treating them as missing will cause substantial positive bias. Our solution to this problem is to define for each fleet (commercial and survey) a minimum detection limit, such that the likelihood of a zero observation is equal to the probability of obtaining an observation below the detection limit. The same solution was used by Cadigan (2015), where the detection limit was set to half of the minimum positive value for the fleet in question. We apply the same detection limit, although the sensitivity of the results to this choice should be evaluated.

	x
1	0.01
2	0.15
3	5.00
4	117.50
5	113.00
6	1.00

Table 1: Detection limits by fleet

The appeal of this method is that the probability of observing a zero depends on the expected value as well as on the variance of that expectation. In other words, lower expected abundance implies that the probability of zero increases, while increasing the variance of that expectation would lead to lower zero probability. This is in contrast to for instance delta-lognormal models where zero probabilities may be estimated independent of the mean and variance of positive observations.

Residuals One-step ahead (OSA) residuals for diagnostics are calculated as described in Berg and Nielsen (2016). These residuals are defined as follows. Let $Y_1 \ldots Y_N$ be the combined vector of scalar observations sorted by time, fleet, and age, then the residual r_i associated with the ith observation is given by

$$r_i = \frac{Y_i - \hat{Y}_{i|i-1}}{\mathrm{sd}\left(Y_{i|i-1}\right)}, \tag{1}$$

where $\hat{Y}_{i|i-1} = E(Y_i|Y_{i-1}, \ldots, Y_1)$ is the OSA prediction of the observation Y_i given $\{Y_1, \ldots, Y_{i-1}\}$, and $\mathrm{sd}\left(Y_{i|i-1}\right)$ is the standard deviation of this prediction. When the observation Y_i is a zero observation, Y_i is replaced with a randomized quantile residual, that is $\Phi^{-1}(U_i)$ where U_i is uniform distributed on $[0, P(Y_i < \text{detection limit})]$.

Forecasting Forecasting is done as follows.

1. Assume values for M, weight-at-age in the catches and in the stock, and maturity-at-age for the projection period.
2. Draw K samples from the joint posterior distribution of the states ($\log N$ and $\log F$) in the last year with data, and the recruitment in all years.
3. Assume that $\log F_t = \log F_{t-S} + \log \psi_t$, for all future values of t where ψ_t is some chosen vector of multipliers of the F-process. If $\psi_t = 1$ for all t this corresponds to assuming the same level and quarterly pattern in F for all future time-steps as in the last data year.
4. Create K forecasting trajectories starting from the samples of joint posterior distribution of the states. The is done by sampling K recruitments directly from the random walk recruitment process estimated by the model, or from the vector of historic recruitments obtained in step 2, and then projecting the states forward in time using the stock equation with randomly sampled process errors from their estimated distribution.
5. Find ψ_t such that the fifth (or any other) percentile of the catches (total mass) in the projections equal some desired level (optional).

Forecasting weight-at-age in the catches There is substantial variation in weight-at-age in the commercial catches from year to year, which means that usual methods of using running averages will be quite sensitive to the bandwidth of the running average. This is important, since TAC estimates calculated in step 5 above depend directly on the catch weight-at-age.

The following models is used:

$$E(\sqrt{CW_{a,q,t}}) = \mu_{a,q} + s(cohort, a) + U_t$$

where $\mu_{a,q}$ is a mean for each combination of quarter and age, $s()$ is tensor product smoothing spline, and U_t are normal distributed random effects . There square root transform is used to achieve variance homogeneity in the residuals.

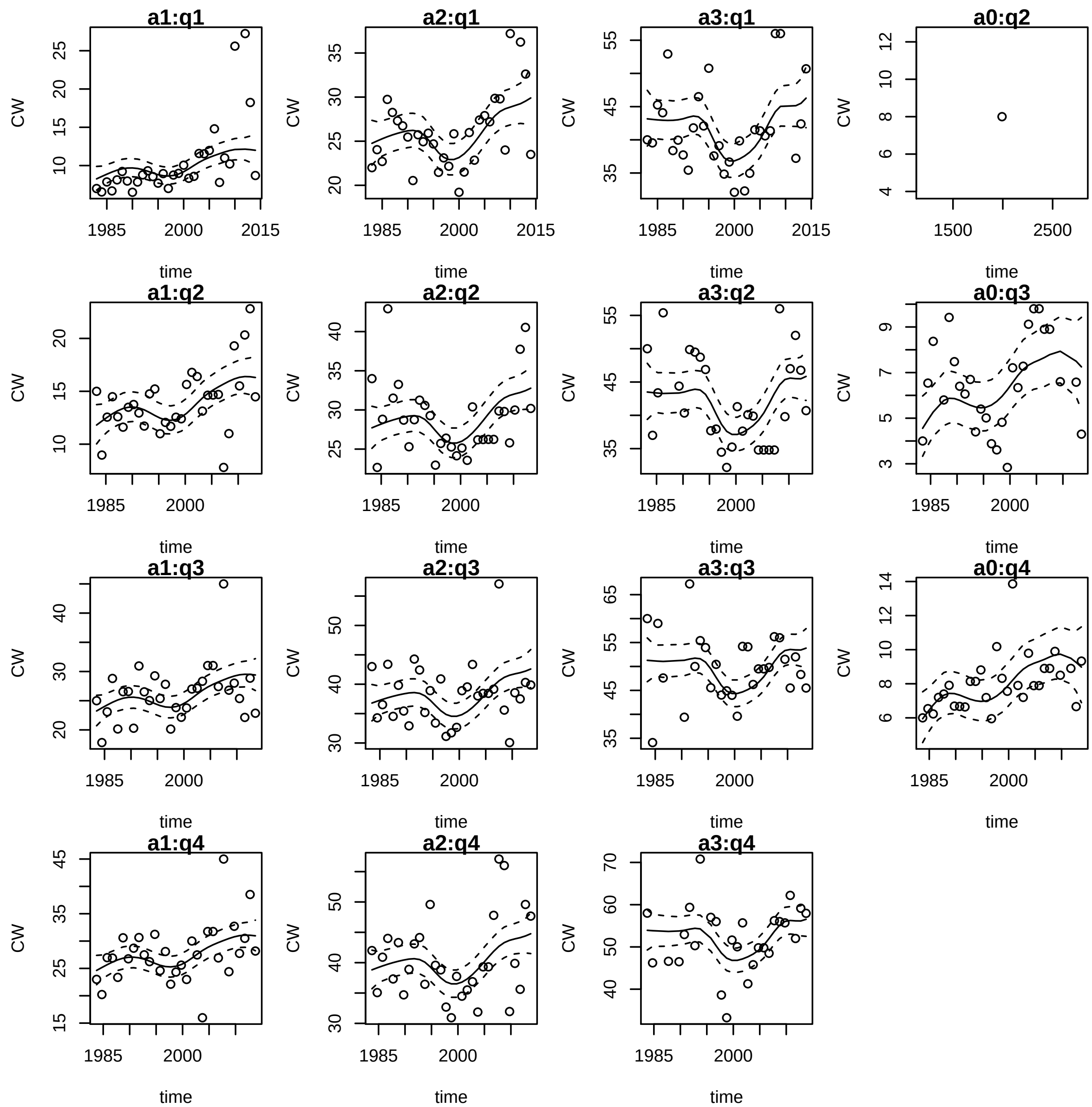


Figure 1: Mean weight in the catches by age and quarter over time

3 Results

The following runs are tried:

1. Base run. Commercial CPUE series omitted. Detection limit set to 0.5 times the smallest positive observation by fleet. Note, that parameter coupling is without row 2 (commercial CPUE fleet). Excluding the years 2005-2008 from the $\log F$ random walk variance estimation (in practice achieved by inflating the standard dev. by a factor of 100 for the involved increments).
2. As the base run but with commercial CPUE series included. Parameter coupling as in appendix.
3. As the base run but detection limit set to 0.99 times the smallest positive observation by fleet.
4. As the base run but detection limit set to 2 times the smallest positive observation by fleet.
5. As the base run but excluding data from 1983 and 1984
6. As the base run but with 0.5 times the natural mortality.
7. As the base run but excluding data from 1983.
8. As the base run but excluding data from 1983, 1984, and 1985.
9. As the base but using all years in the $\log F$ RW variance estimation.

3.1 Run 1 (base run)

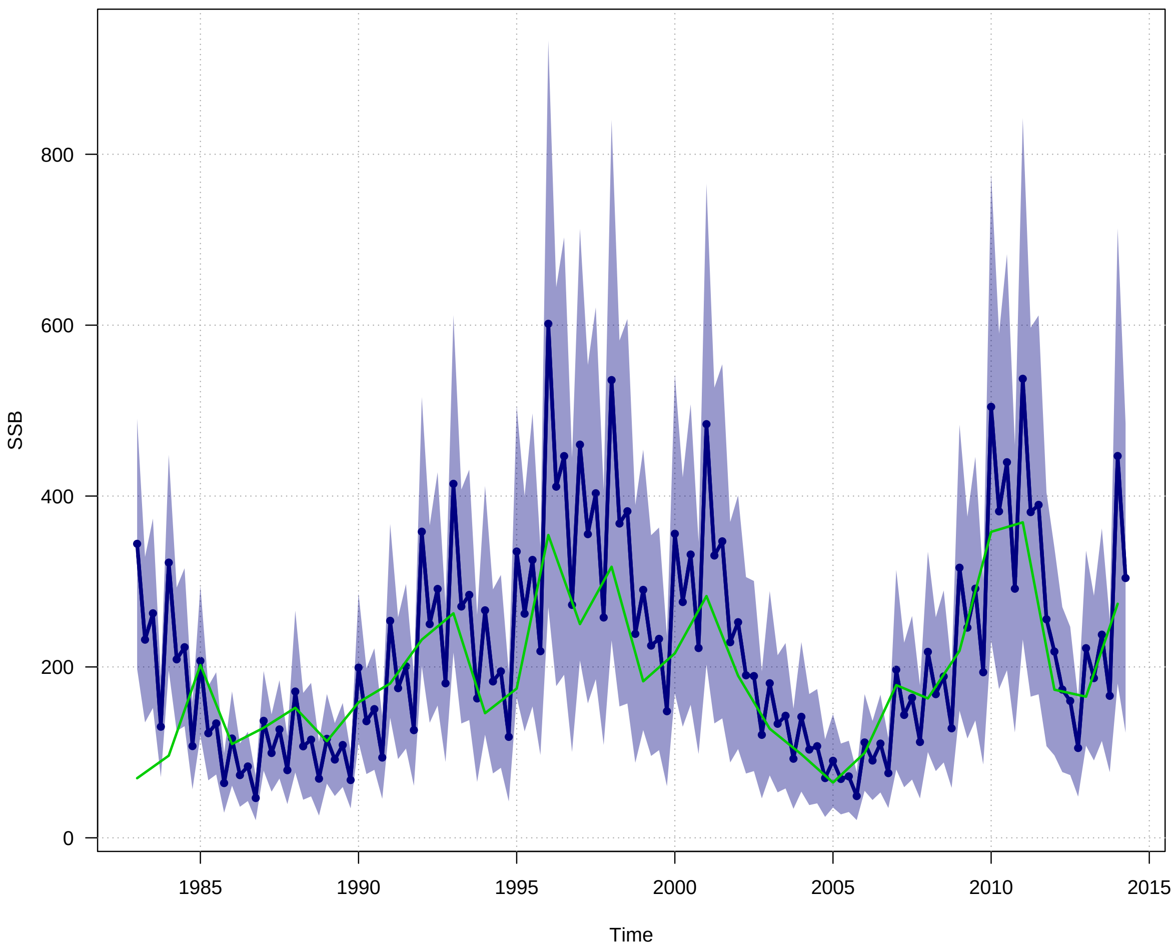


Figure 2: SSB: Blue is SESAM, green is XSA (May 2014).

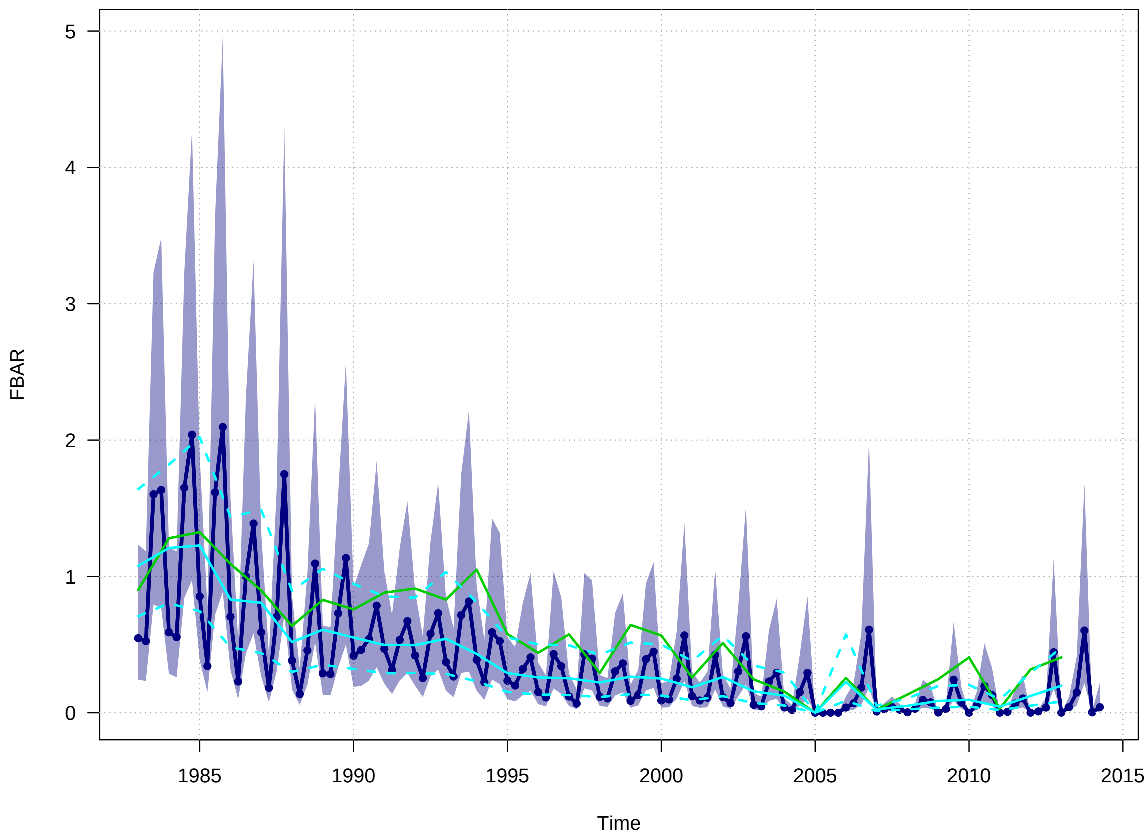


Figure 3: $\bar{F}_{1-2}$: Blue is SESAM by quarter, cyan is SESAM yearly average, green is XSA yearly average.

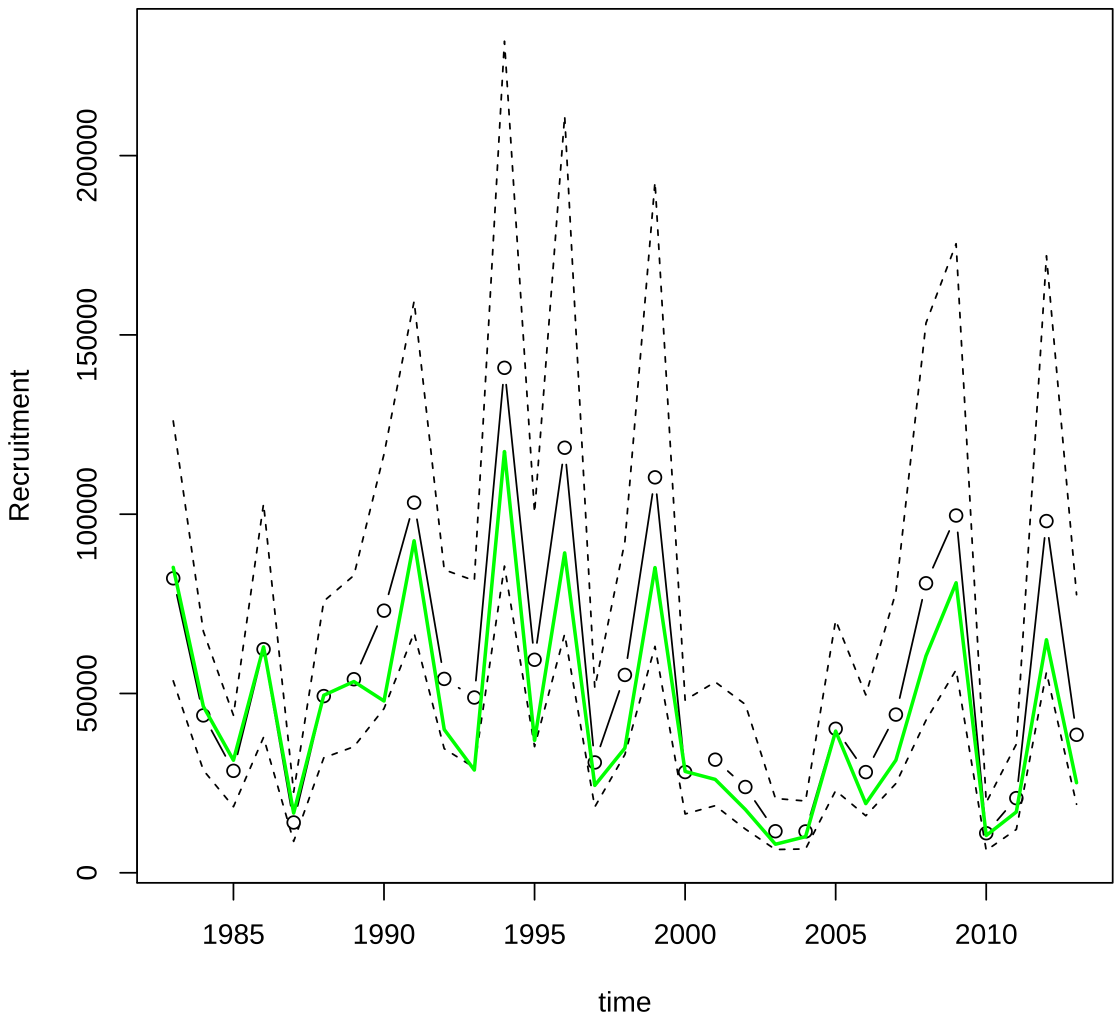


Figure 4: Recruitment: Black is SESAM, green is XSA.

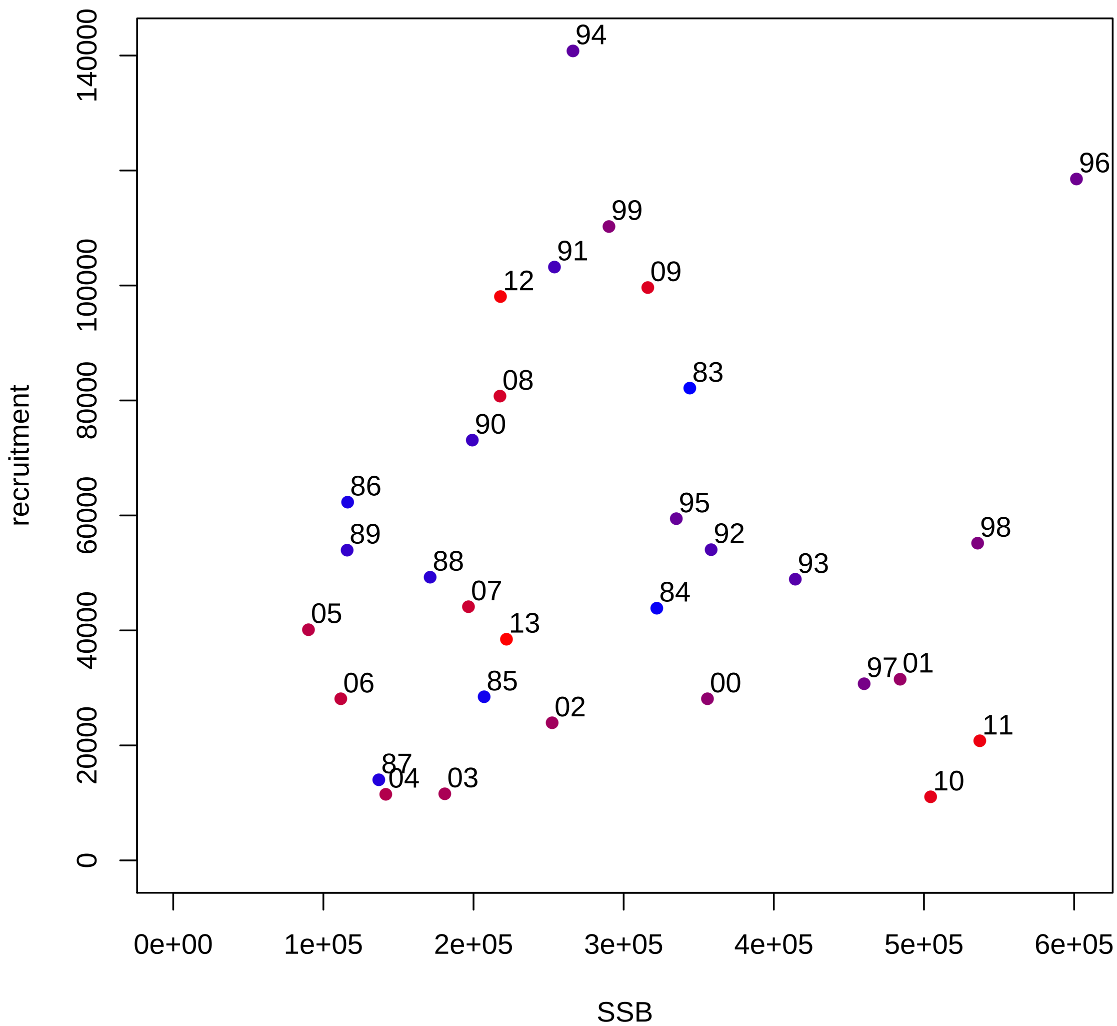


Figure 5: Stock-Recruitment from SESAM. SSB is calculated in Q1, whereas recruitment is in Q3.

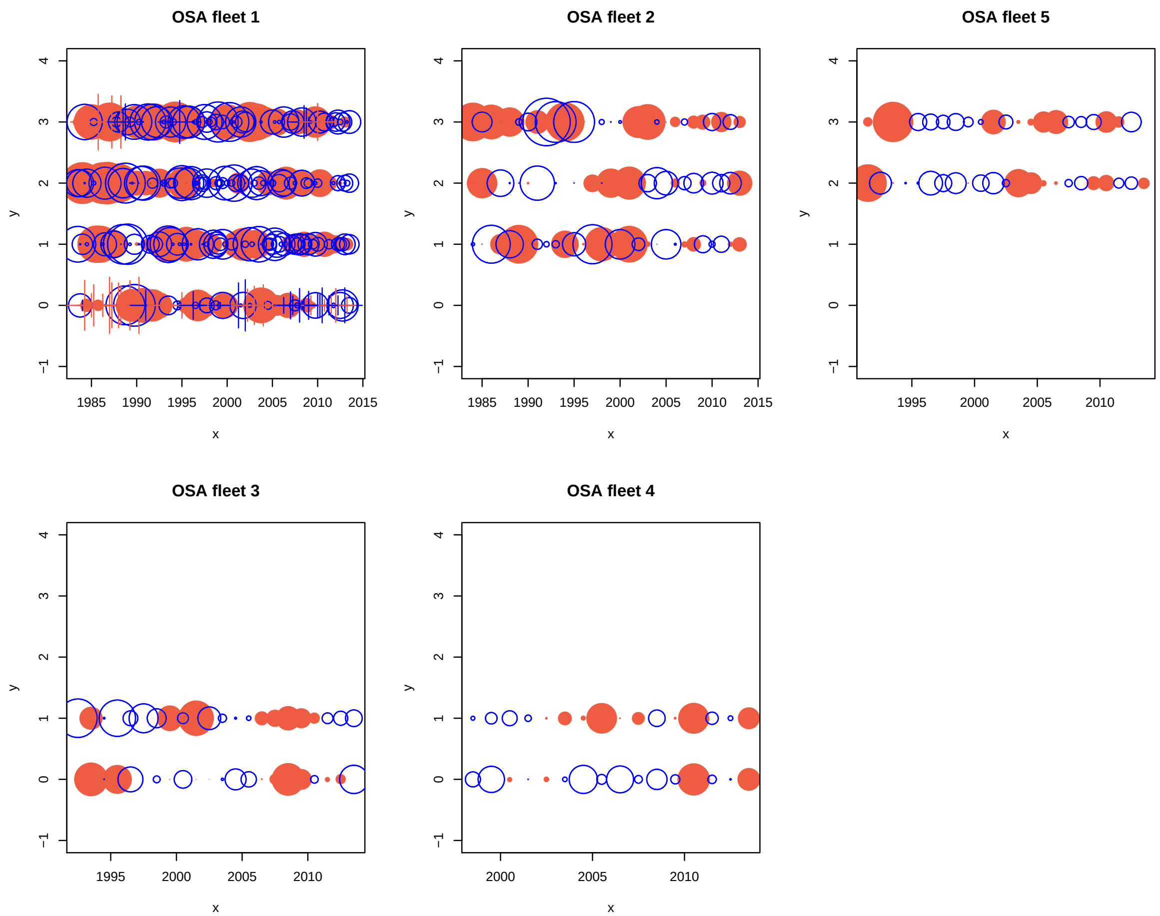


Figure 6: SESAM one-step ahead residuals by fleet. Circles are used for positive observations while '+' denotes randomized residuals from zero observations. Blue is positive, red is negative.

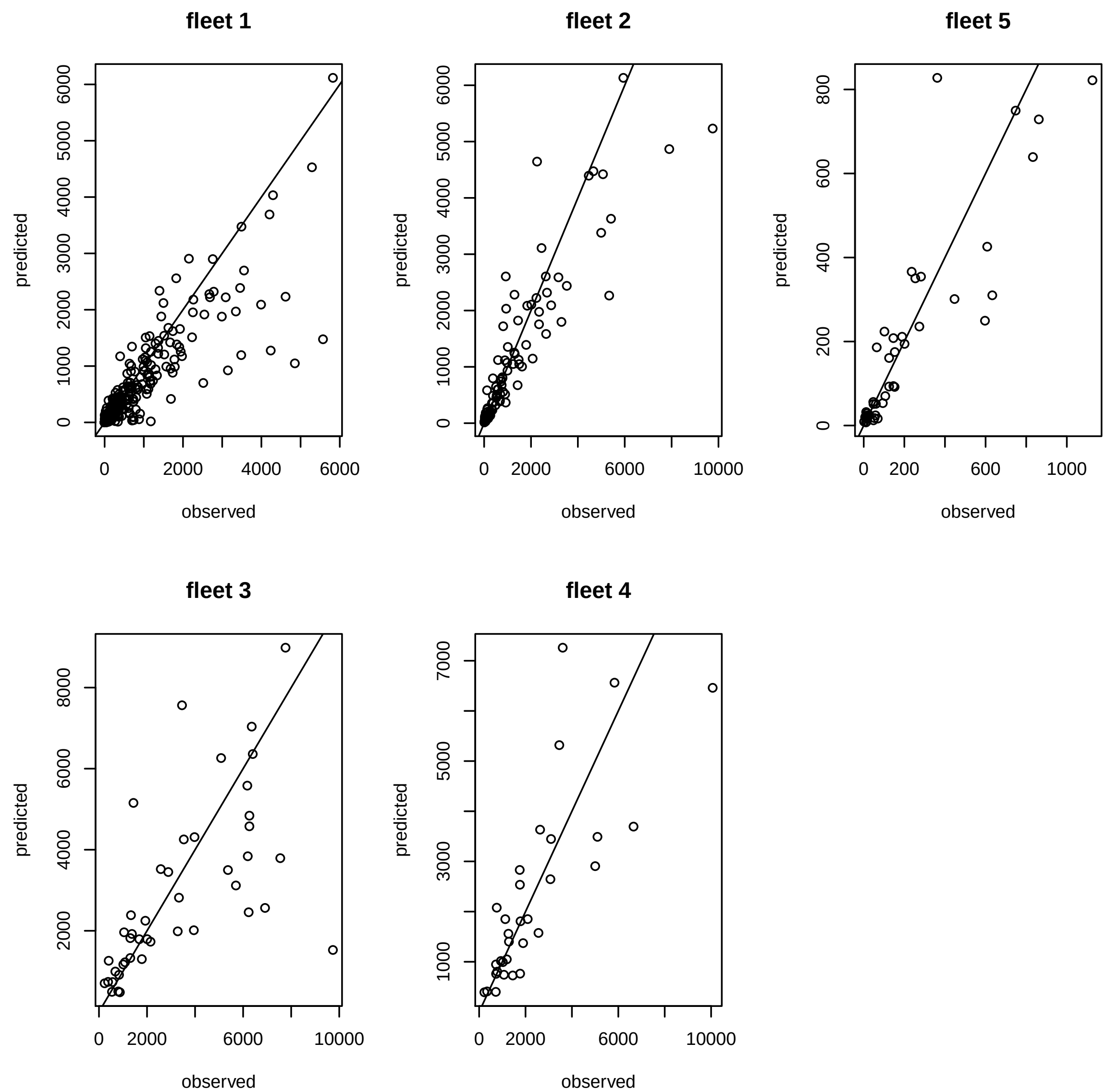


Figure 7: Observed versus predicted.

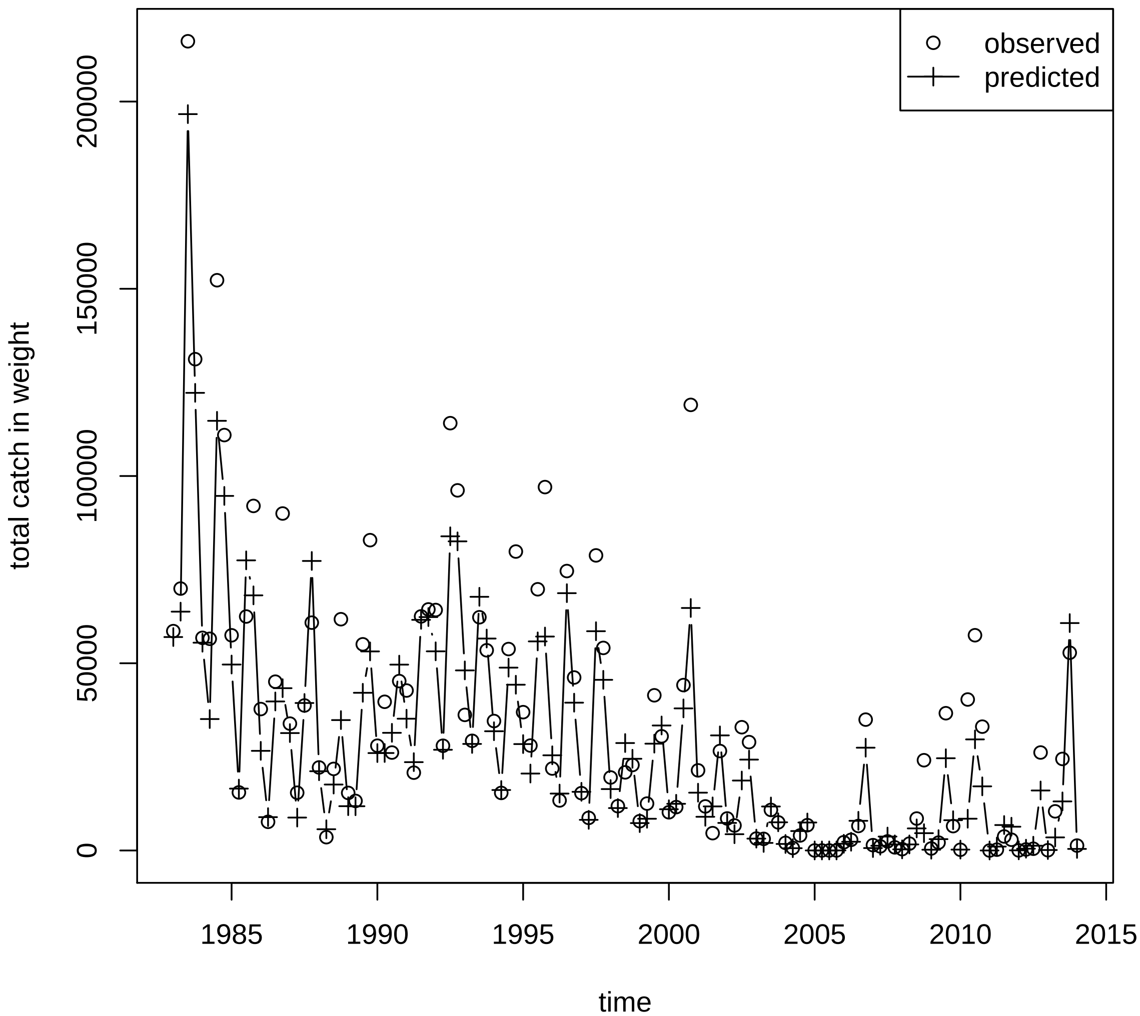


Figure 8: Total catch weight observed versus predicted by quarter.

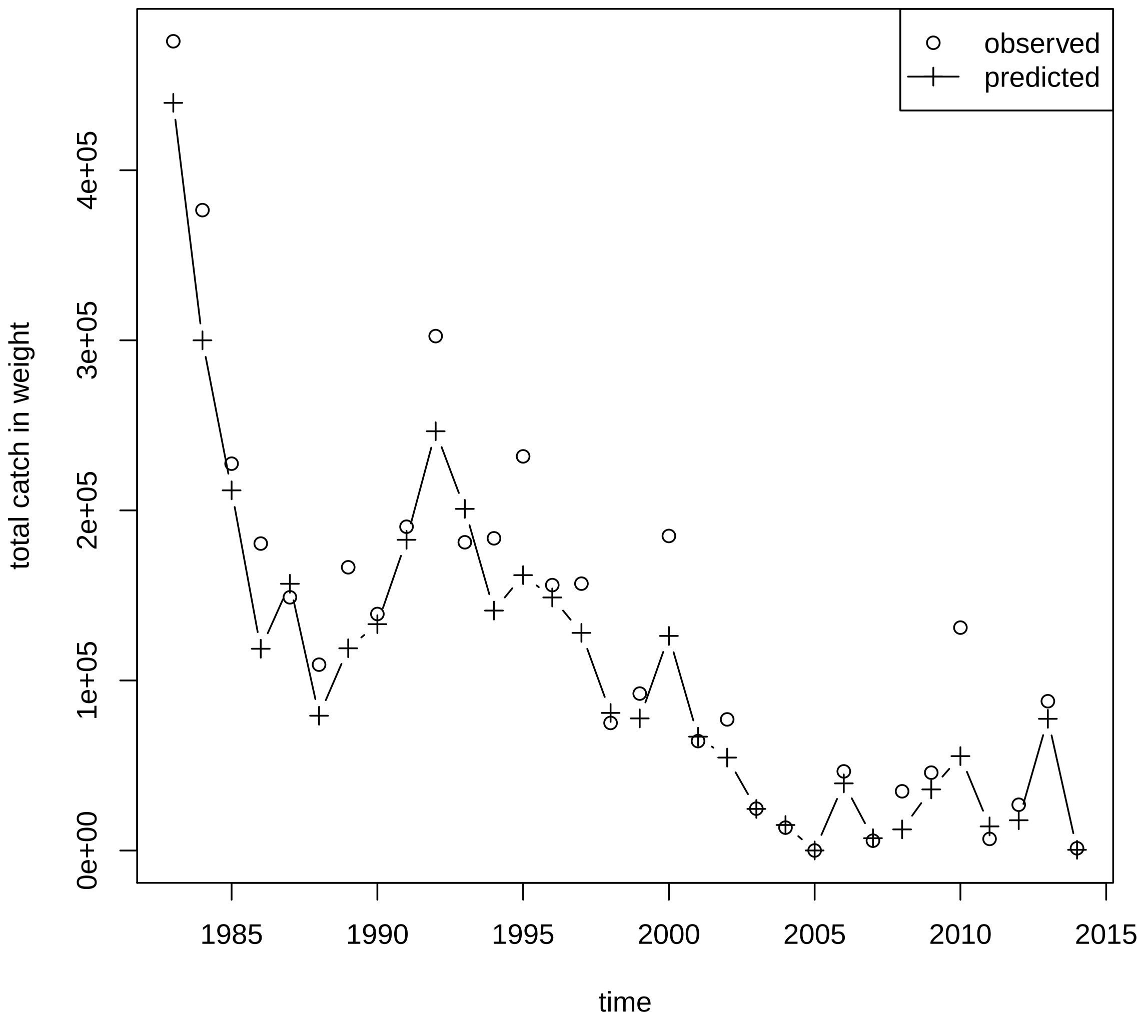


Figure 9: Total catch weight observed versus predicted by year.

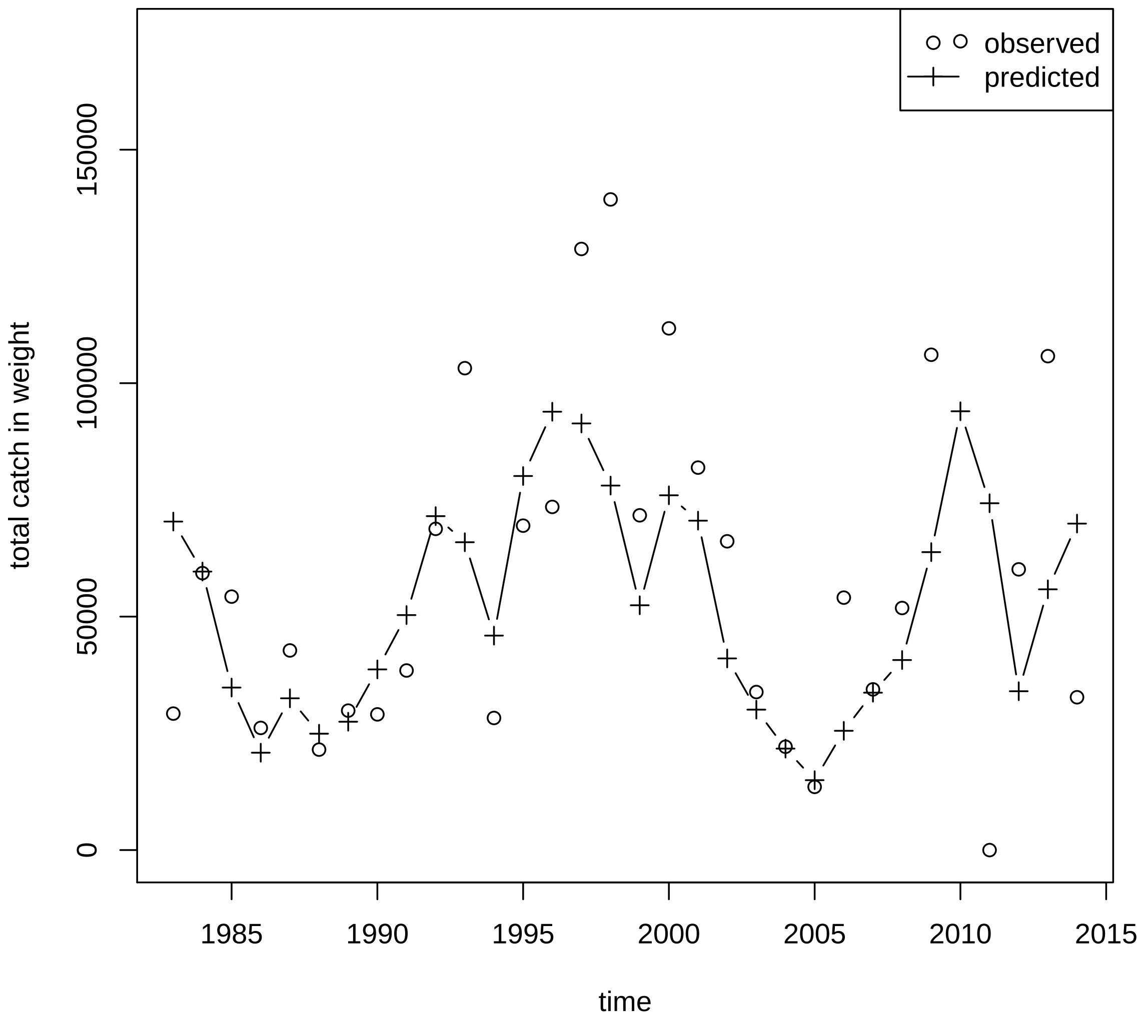


Figure 10: Total catch weight in the IBTSQ1 survey observed versus predicted by year.

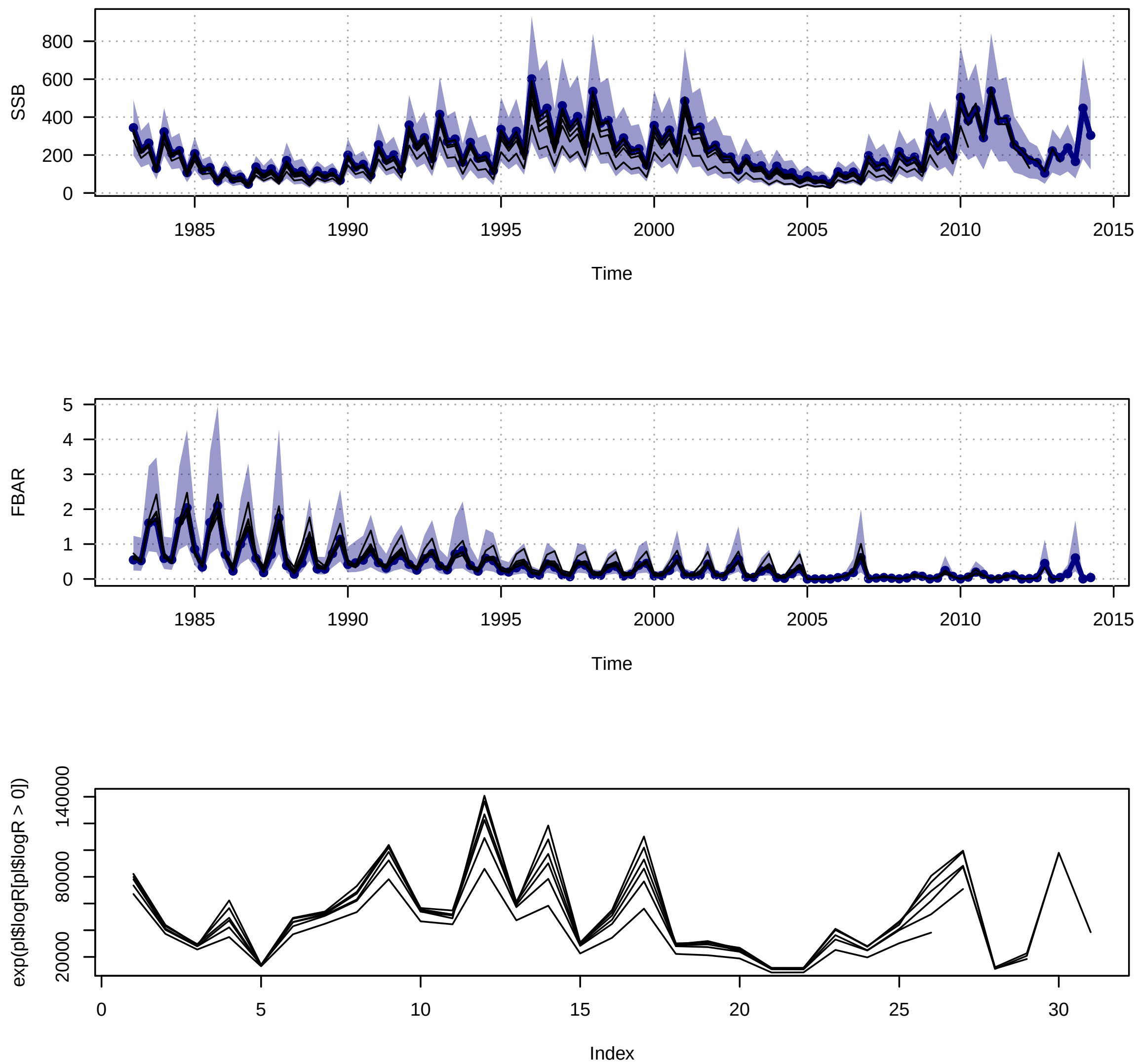


Figure 11: Retrospective diagnostic run.

	time	SSB	lo	hi
1	1983	344.11	223.70	464.51
2	1984	322.11	218.26	425.96
3	1985	207.14	135.02	279.26
4	1986	116.24	70.83	161.64
5	1987	136.95	88.94	184.95
6	1988	171.21	93.27	249.16
7	1989	115.86	72.68	159.05
8	1990	199.25	127.51	270.99
9	1991	254.00	160.67	347.32
10	1992	358.31	228.71	487.92
11	1993	414.32	251.83	576.82
12	1994	266.26	146.54	385.99
13	1995	335.10	194.93	475.27
14	1996	601.62	328.84	874.39
15	1997	460.20	252.41	668.00
16	1998	535.74	285.18	786.31
17	1999	290.21	155.25	425.17
18	2000	355.88	202.35	509.41
19	2001	484.14	252.64	715.65
20	2002	252.38	130.24	374.52
21	2003	180.93	92.17	269.69
22	2004	141.64	69.60	213.68
23	2005	90.13	45.19	135.07
24	2006	111.62	65.04	158.21
25	2007	196.74	100.61	292.86
26	2008	217.67	121.24	314.10
27	2009	316.15	178.47	453.83
28	2010	504.44	279.95	728.93
29	2011	537.27	286.28	788.26
30	2012	218.03	118.06	317.99
31	2013	221.96	128.05	315.88
32	2014	446.88	227.83	665.92

Table 2: SSB in Q1. 'lo' and 'hi' is the 5 and 95 percentiles respectively

	time	SSB	recruitment
1	1983.00	344.11	82123.02
2	1984.00	322.11	43893.23
3	1985.00	207.14	28436.83
4	1986.00	116.24	62344.17
5	1987.00	136.95	14025.64
6	1988.00	171.21	49275.35
7	1989.00	115.86	53982.47
8	1990.00	199.25	73101.64
9	1991.00	254.00	103235.93
10	1992.00	358.31	54074.28
11	1993.00	414.32	48880.39
12	1994.00	266.26	140825.54
13	1995.00	335.10	59414.23
14	1996.00	601.62	118543.36
15	1997.00	460.20	30767.34
16	1998.00	535.74	55181.80
17	1999.00	290.21	110283.79
18	2000.00	355.88	28101.83
19	2001.00	484.14	31550.92
20	2002.00	252.38	23921.37
21	2003.00	180.93	11588.23
22	2004.00	141.64	11528.77
23	2005.00	90.13	40163.83
24	2006.00	111.62	28079.75
25	2007.00	196.74	44117.49
26	2008.00	217.67	80740.48
27	2009.00	316.15	99636.26
28	2010.00	504.44	11036.81
29	2011.00	537.27	20817.80
30	2012.00	218.03	98083.09
31	2013.00	221.96	38491.38

Table 3: Estimated SSB in Q1 and recruitment in Q3

	time	fbar	fbar5	ssb	ssb5
1	2014.25	0.04	0.02	320.77	197.04
2	2014.50	0.15	0.06	354.36	217.00
3	2014.75	0.62	0.26	231.08	136.84
4	2015.00	0.00	0.00	286.84	168.47
5	2015.25	0.04	0.02	224.93	131.67
6	2015.50	0.15	0.06	233.54	132.00
7	2015.75	0.62	0.26	153.27	84.56
8	2016.00	0.00	0.00	236.82	112.36

Table 4: Forecast given status quo F. ’fbar5’ and ’ssb5’ are the 5th percentiles

	time	fbar	fbar5.0	ssb	ssb5
1	2014.25	0.00	0.00	321.19	197.32
2	2014.50	0.00	0.00	360.10	222.37
3	2014.75	0.00	0.00	247.26	152.48
4	2015.00	0.00	0.00	337.98	216.54
5	2015.25	0.00	0.00	262.98	167.40
6	2015.50	0.00	0.00	277.09	170.34
7	2015.75	0.00	0.00	188.47	115.40
8	2016.00	0.00	0.00	316.41	156.37

Table 5: Forecast given zero F. 'fbar5' and 'ssb5' are the 5th percentiles

Parameter estimates

```
                Estimate   Std. Error
logSdLogFsta -0.42148852 1.901621e-01
logSdLogN    -3.64022923 2.138309e+01
logSdLogObs   0.89954656 6.226468e-02
logSdLogObs  -0.36959586 9.229369e-02
logSdLogObs  -0.63475329 8.925200e-02
logSdLogObs  -0.50644743 1.221702e-01
logSdLogObs  -0.77487756 1.477536e-01
logSdLogObs  -0.42203995 1.164322e-01
logQ         -2.37885584 2.007455e-01
logQ         -1.81673519 2.342258e-01
logQ         -1.82920090 3.419413e-01
logQ         -2.57733713 2.443985e-01
logQ         -1.78751162 2.512312e-01
logQ         -2.50255656 2.494839e-01
logQ         -1.95196151 2.561078e-01
logQ         -1.91138013 2.985827e-01
logQ         -2.76633691 3.634329e-01
trans_rho     5.30094463 4.697853e-01
logSdLogR    -0.07995401 1.481646e-01
rho           0.99995026 4.673001e-05
```

3.2 Run 2

In run 2 the commercial CPUE fleet has been included. $\log F$ RW variance inflated for years with closed fishery.

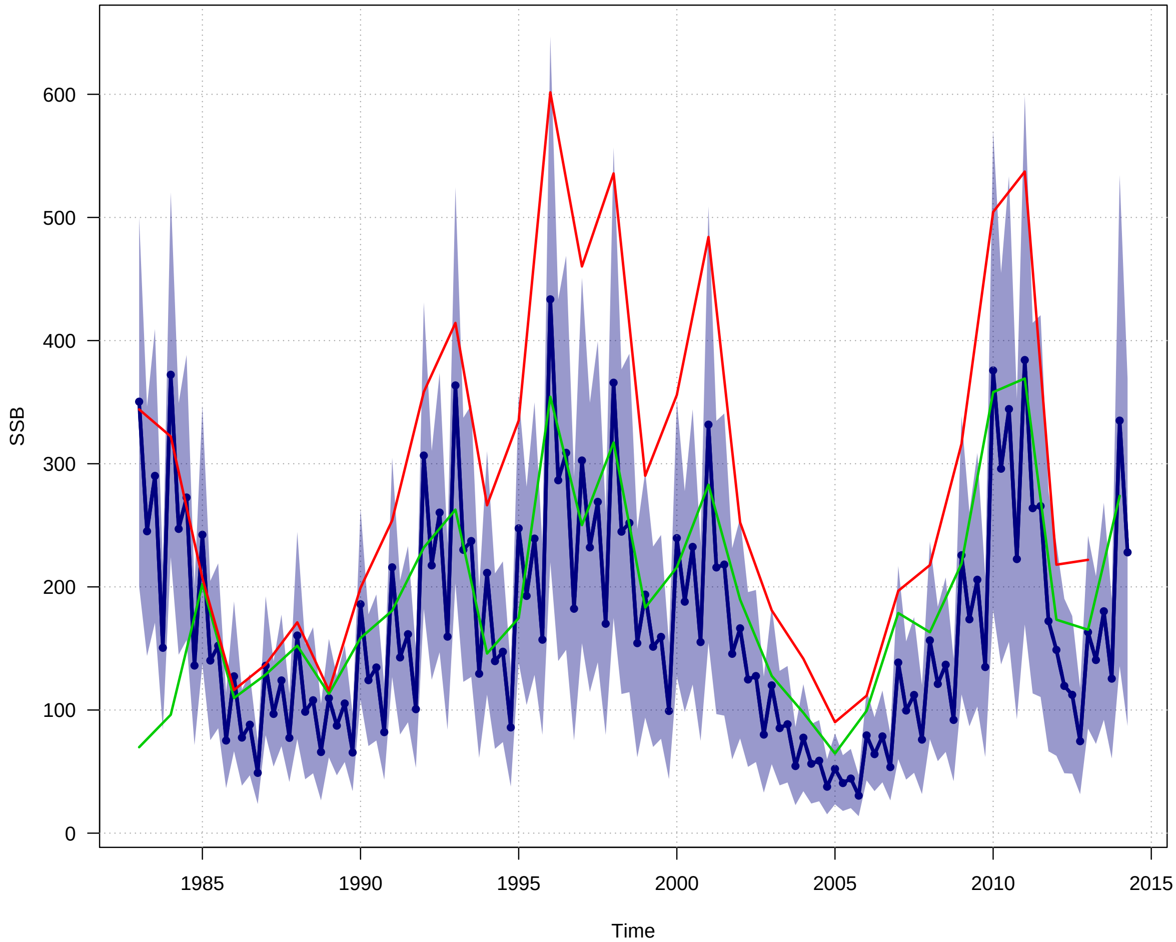


Figure 12: **Run 2** SSB: Blue is SESAM, green is XSA (May 2014), red is the base run.

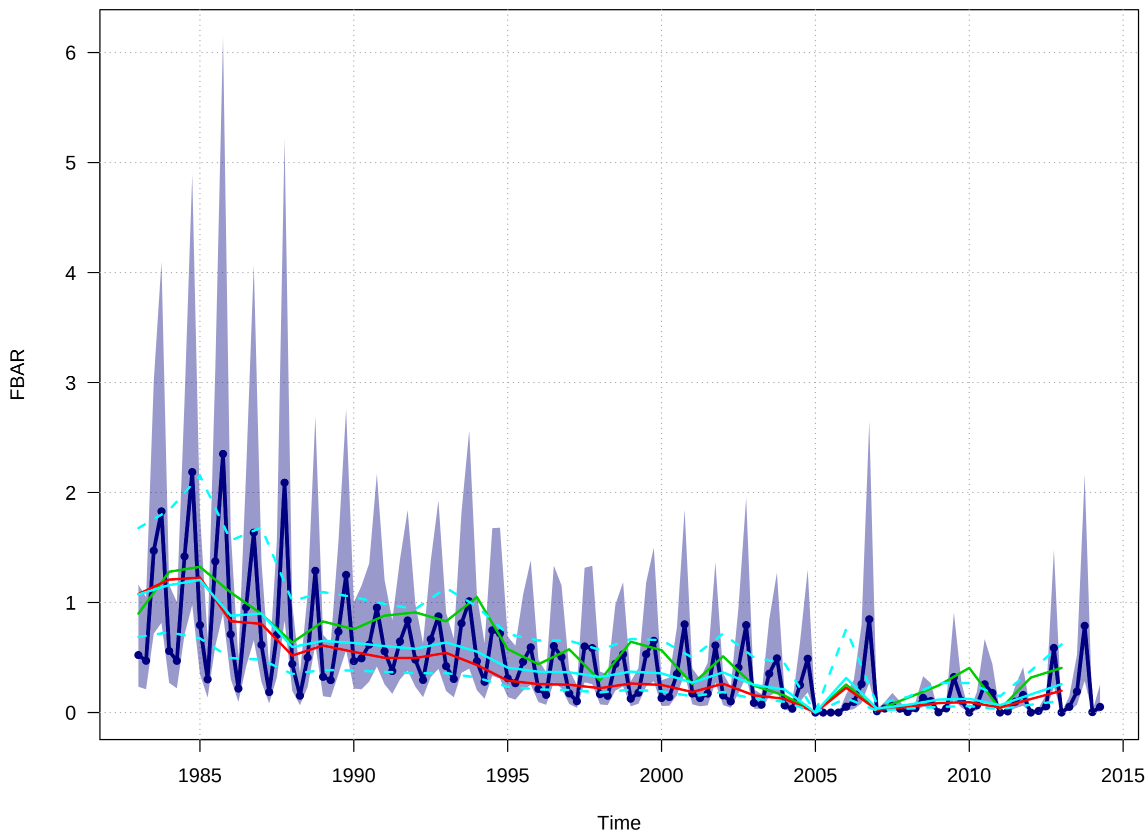


Figure 13: **Run 2** $\bar{F}_{1-2}$: Blue is SESAM by quarter, cyan is SESAM yearly average, green is XSA yearly average.

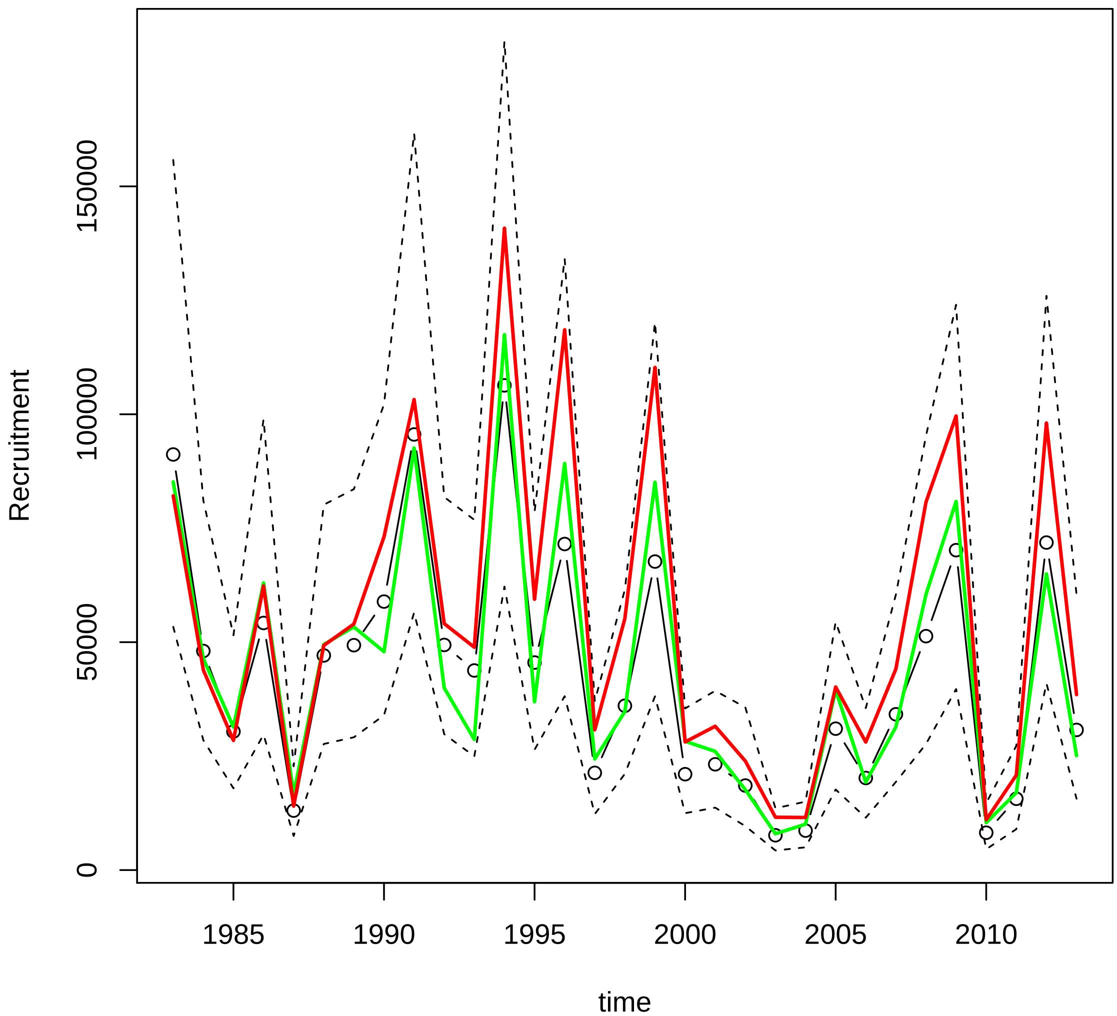
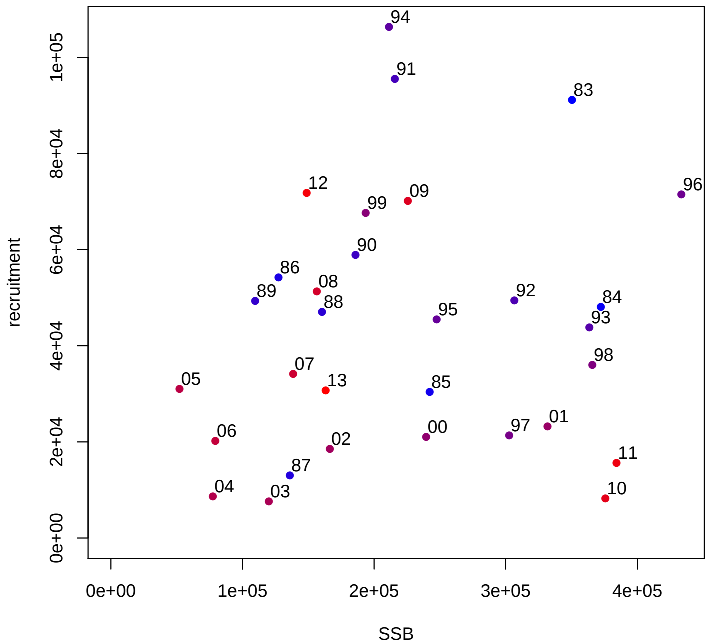


Figure 14: **Run 2** Recruitment: Black is SESAM, green is XSA.



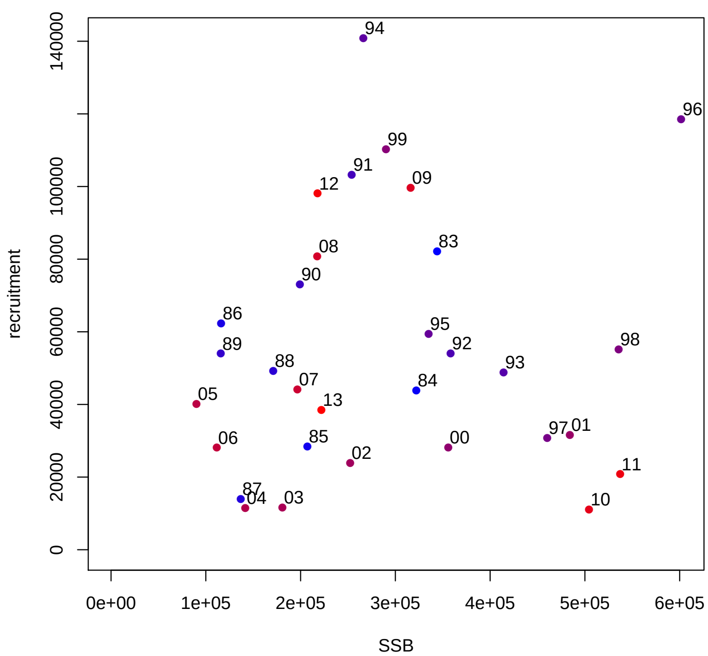


Figure 15: **Run 2** Stock-Recruitment from SESAM (top). SSB is calculated in Q1, whereas recruitment is in Q3. Bottom figure is base run.

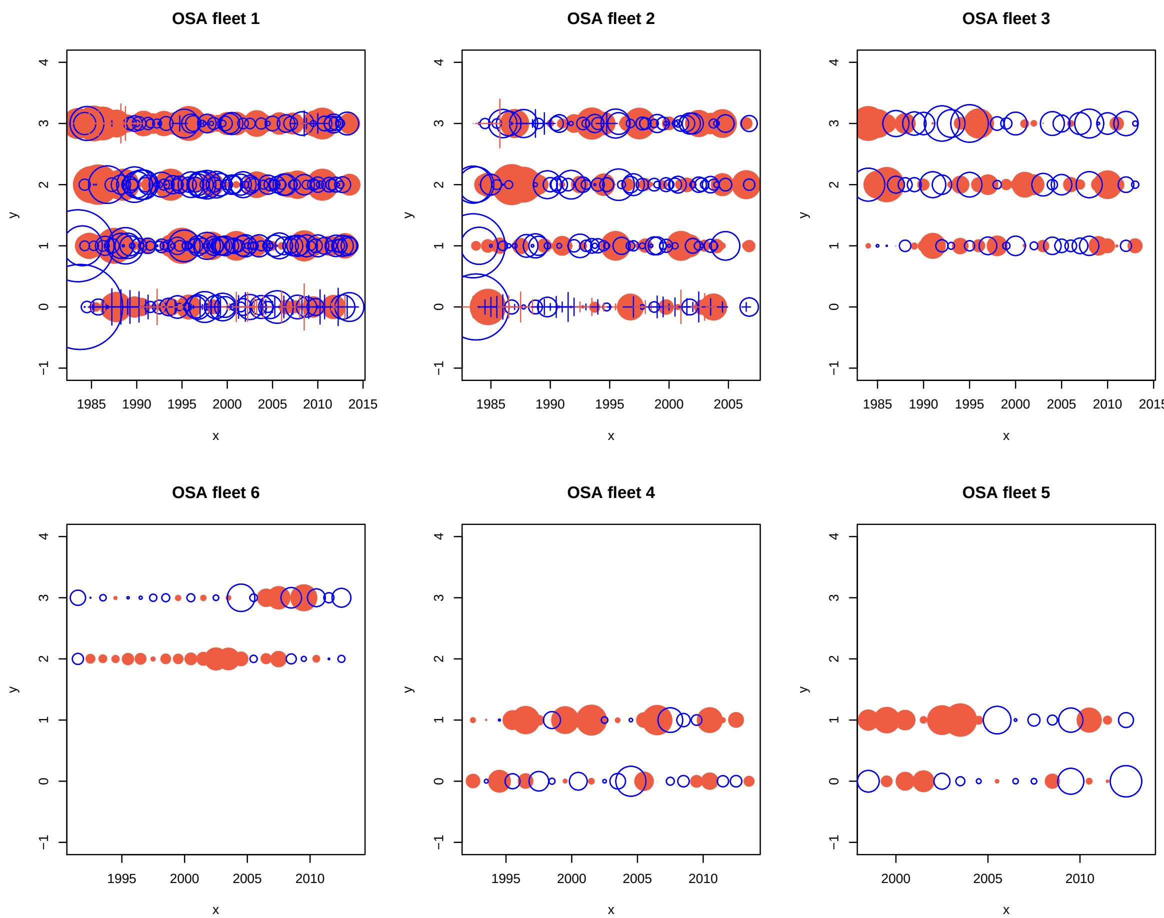


Figure 16: **Run 2** SESAM one-step ahead residuals by fleet. Circles are used for positive observations while '+' denotes randomized residuals from zero observations. Blue is positive, red is negative.

	time	SSB	lo	hi
1	1983	350.40	226.99	473.80
2	1984	372.28	250.43	494.12
3	1985	242.34	155.97	328.71
4	1986	127.37	77.32	177.43
5	1987	135.96	89.50	182.42
6	1988	160.50	91.30	229.71
7	1989	109.66	70.04	149.29
8	1990	185.91	122.03	249.79
9	1991	215.88	142.63	289.12
10	1992	306.67	204.29	409.06
11	1993	363.62	231.23	496.00
12	1994	211.39	130.02	292.75
13	1995	247.54	157.96	337.11
14	1996	433.52	257.88	609.16
15	1997	302.63	180.57	424.70
16	1998	365.82	208.67	522.97
17	1999	193.70	111.56	275.84
18	2000	239.60	147.22	331.99
19	2001	331.77	185.91	477.64
20	2002	166.37	92.74	239.99
21	2003	120.02	67.38	172.67
22	2004	77.54	41.77	113.30
23	2005	52.22	28.50	75.95
24	2006	79.41	49.33	109.48
25	2007	138.56	74.08	203.04
26	2008	156.57	90.58	222.57
27	2009	225.70	132.70	318.70
28	2010	375.79	215.85	535.74
29	2011	384.24	207.60	560.88
30	2012	148.83	78.11	219.55
31	2013	163.22	98.83	227.60
32	2014	335.05	171.04	499.06

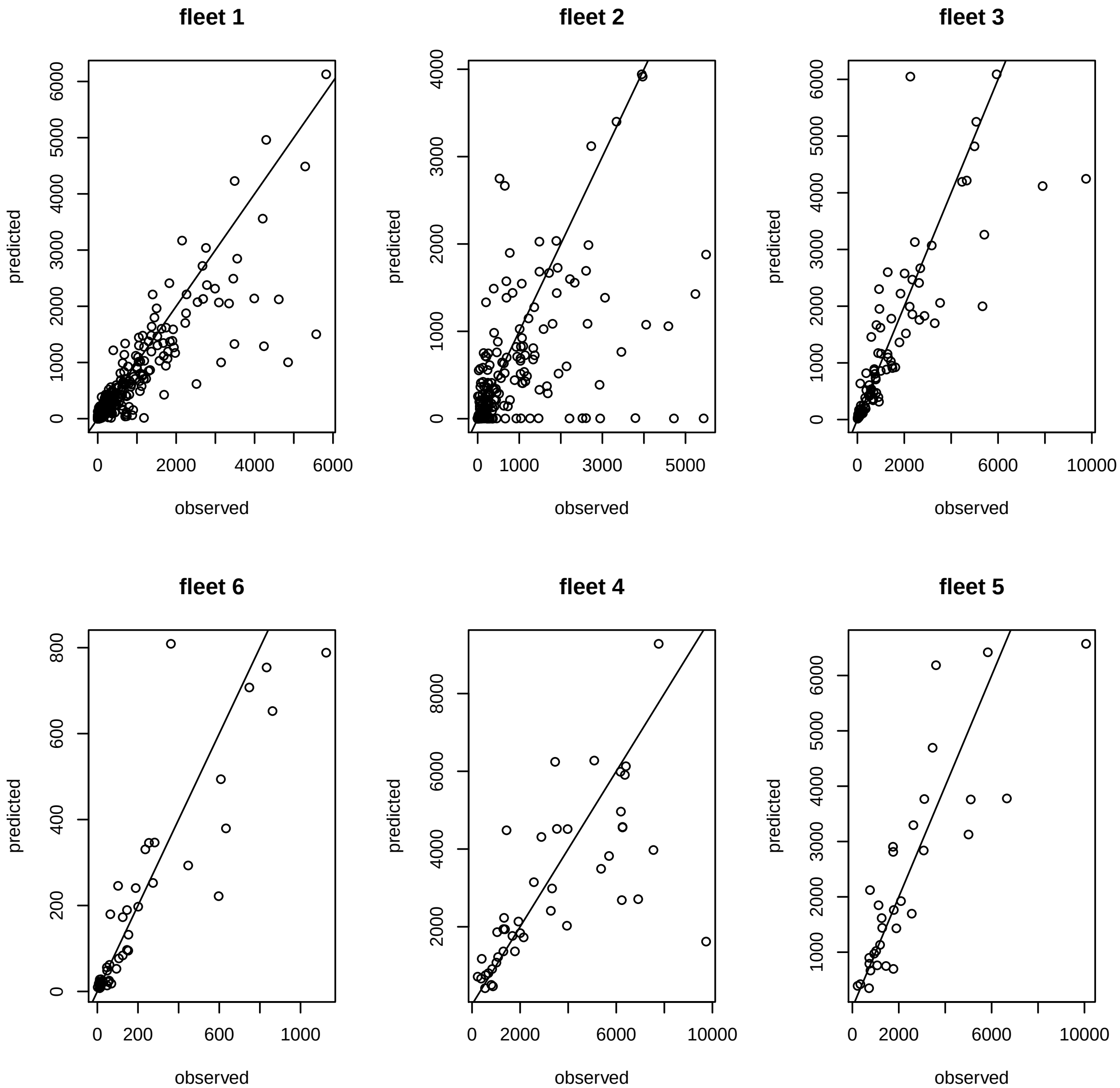
Table 6: SSB in Q1. 'lo' and 'hi' is the 5 and 95 percentiles respectively

	time	SSB	recruitment
1	1983.00	350.40	91184.18
2	1984.00	372.28	48068.76
3	1985.00	242.34	30393.65
4	1986.00	127.37	54215.11
5	1987.00	135.96	13047.64
6	1988.00	160.50	47090.82
7	1989.00	109.66	49341.05
8	1990.00	185.91	58910.29
9	1991.00	215.88	95576.96
10	1992.00	306.67	49395.83
11	1993.00	363.62	43794.25
12	1994.00	211.39	106346.54
13	1995.00	247.54	45535.96
14	1996.00	433.52	71539.94
15	1997.00	302.63	21332.39
16	1998.00	365.82	36054.68
17	1999.00	193.70	67690.03
18	2000.00	239.60	21038.49
19	2001.00	331.77	23212.01
20	2002.00	166.37	18549.47
21	2003.00	120.02	7634.38
22	2004.00	77.54	8655.31
23	2005.00	52.22	31026.83
24	2006.00	79.41	20208.43
25	2007.00	138.56	34184.27
26	2008.00	156.57	51324.32
27	2009.00	225.70	70186.91
28	2010.00	375.79	8202.78
29	2011.00	384.24	15646.75
30	2012.00	148.83	71858.47
31	2013.00	163.22	30751.77

Table 7: Estimated SSB in Q1 and recruitment in Q3

	time	fbar	fbar5	ssb	ssb5
1	2014.25	0.05	0.02	242.60	139.15
2	2014.50	0.19	0.09	268.55	146.48
3	2014.75	0.80	0.35	173.46	87.94
4	2015.00	0.00	0.00	218.36	111.07
5	2015.25	0.05	0.02	173.35	85.78
6	2015.50	0.19	0.09	183.49	85.75
7	2015.75	0.80	0.35	120.63	53.59
8	2016.00	0.00	0.00	181.28	75.09

Table 8: Forecast given status quo F. 'fbar5' and 'ssb5' are the 5th percentiles



[!htb]

Figure 17: **Run 2** Observed versus predicted.

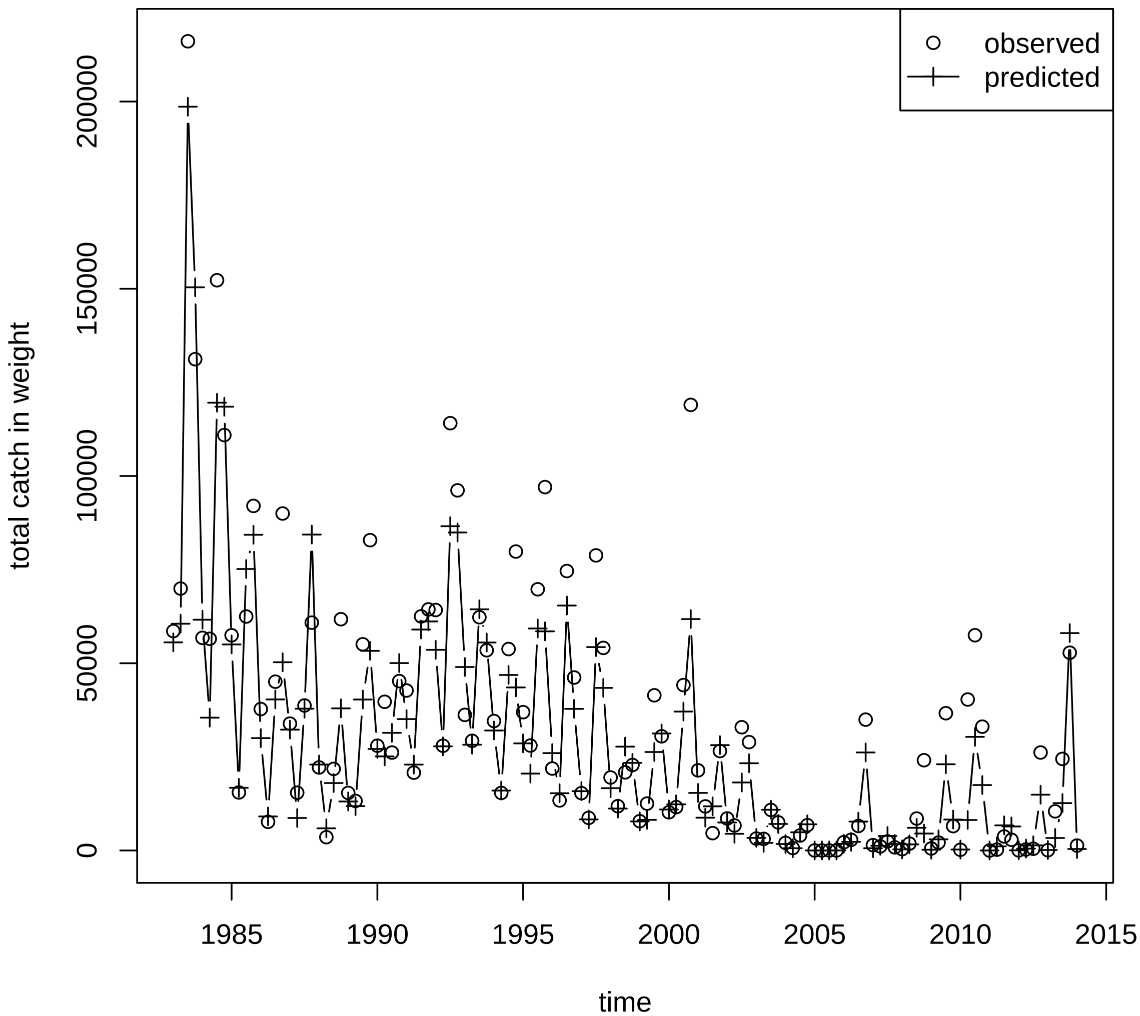


Figure 18: Total catch weight observed versus predicted by quarter.

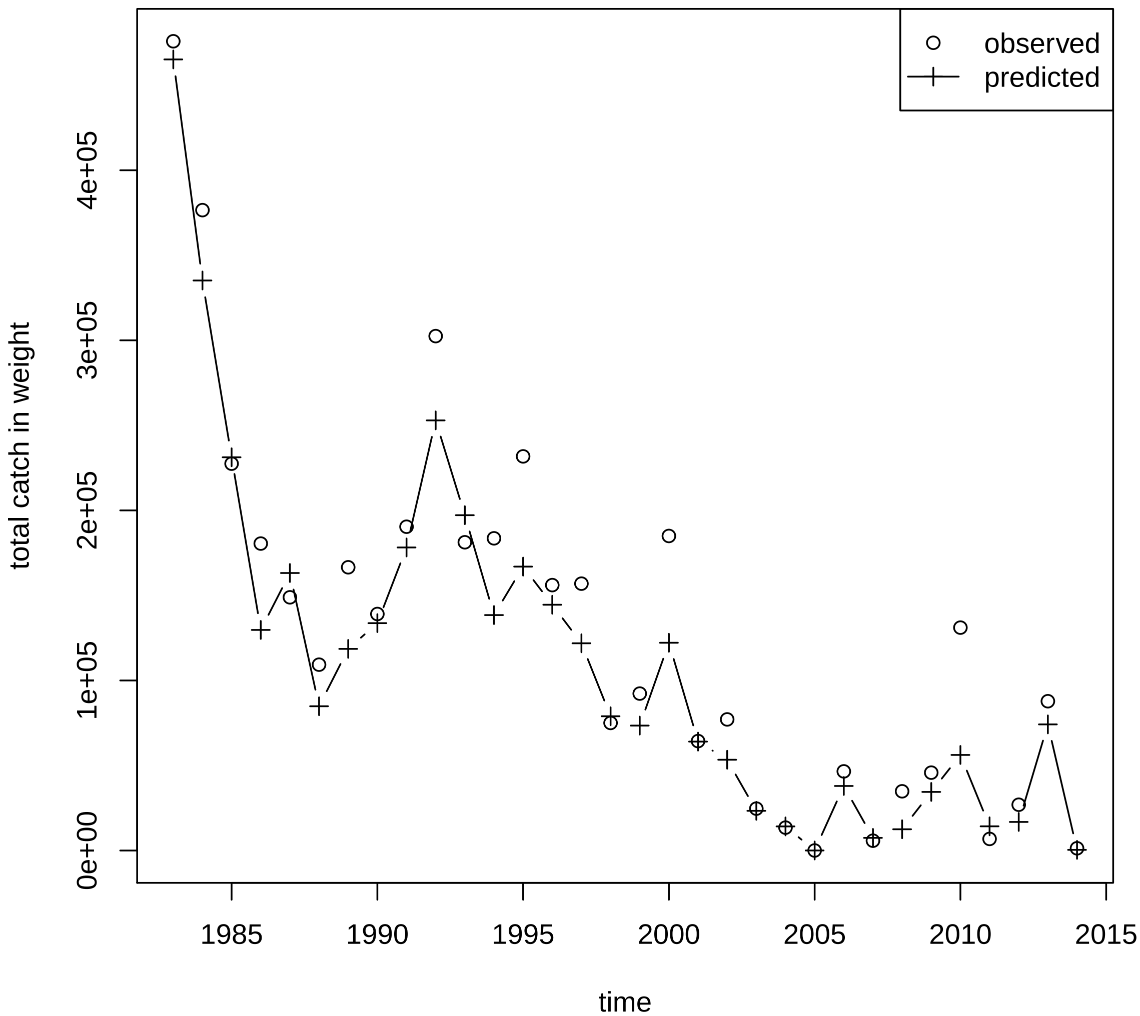


Figure 19: Total catch weight observed versus predicted by year.

	time	fbar	fbar5.0	ssb	ssb5
1	2014.25	0.00	0.00	242.92	139.35
2	2014.50	0.00	0.00	274.00	151.03
3	2014.75	0.00	0.00	190.00	99.25
4	2015.00	0.00	0.00	269.22	149.75
5	2015.25	0.00	0.00	213.10	113.95
6	2015.50	0.00	0.00	230.18	115.29
7	2015.75	0.00	0.00	158.14	76.67
8	2016.00	0.00	0.00	264.69	114.52

Table 9: Forecast given zero F. 'fbar5' and 'ssb5' are the 5th percentiles

Parameter estimates

```
                Estimate   Std. Error
logSdLogFsta -0.51231046 2.391020e-01
logSdLogN    -1.58271380 5.802301e-01
logSdLogObs   0.90068124 6.280415e-02
logSdLogObs  -0.36990021 1.027052e-01
logSdLogObs   1.39562351 8.308373e-02
logSdLogObs  -0.01025582 7.012222e-02
logSdLogObs  -0.58756218 9.389995e-02
logSdLogObs  -0.55331645 1.259494e-01
logSdLogObs  -0.76221636 1.556728e-01
logSdLogObs  -0.43611115 1.222855e-01
logQ         -9.20505003 6.619155e-01
logQ         -2.58270006 1.897436e-01
logQ         -1.81167309 2.509339e-01
logQ         -3.54017411 6.341643e-01
logQ         -2.14778553 1.797332e-01
logQ         -1.57267557 2.095101e-01
logQ         -1.48450223 3.421031e-01
logQ         -2.26392186 2.126941e-01
logQ         -1.46697077 2.169489e-01
logQ         -2.17426240 2.199151e-01
logQ         -1.60196128 2.241499e-01
logQ         -1.53405769 2.703287e-01
logQ         -2.30072593 3.753525e-01
trans_rho     5.11185124 4.543706e-01
logSdLogR    -0.12334838 1.659673e-01
rho           0.99992740 6.596919e-05
```

3.3 Run 3

In run 3 the detection limit has been set to 0.99 times the smallest observation greater than zero by fleet.

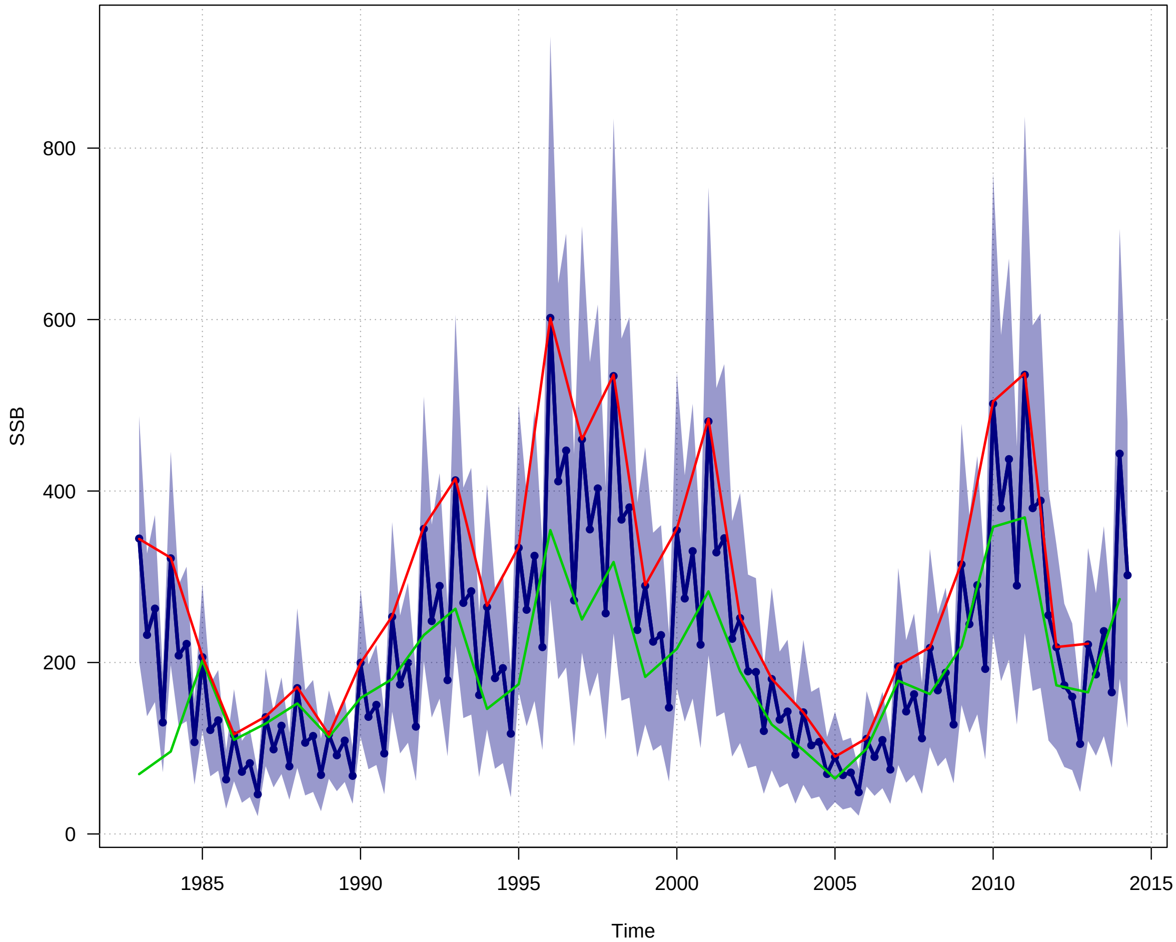


Figure 20: **Run 3** SSB: Blue is SESAM, green is XSA (May 2014), red is the base run.

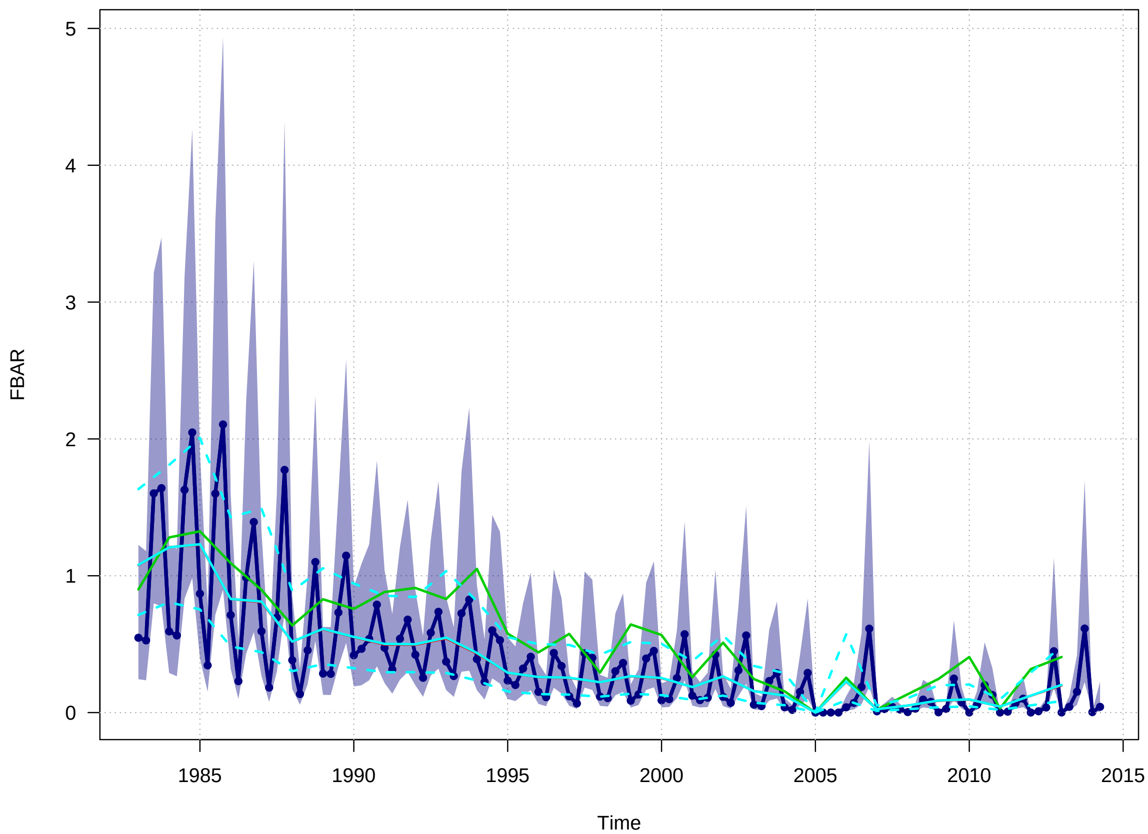


Figure 21: **Run 3** $\bar{F}_{1-2}$: Blue is SESAM by quarter, cyan is SESAM yearly average, green is XSA yearly average, red is the base run.

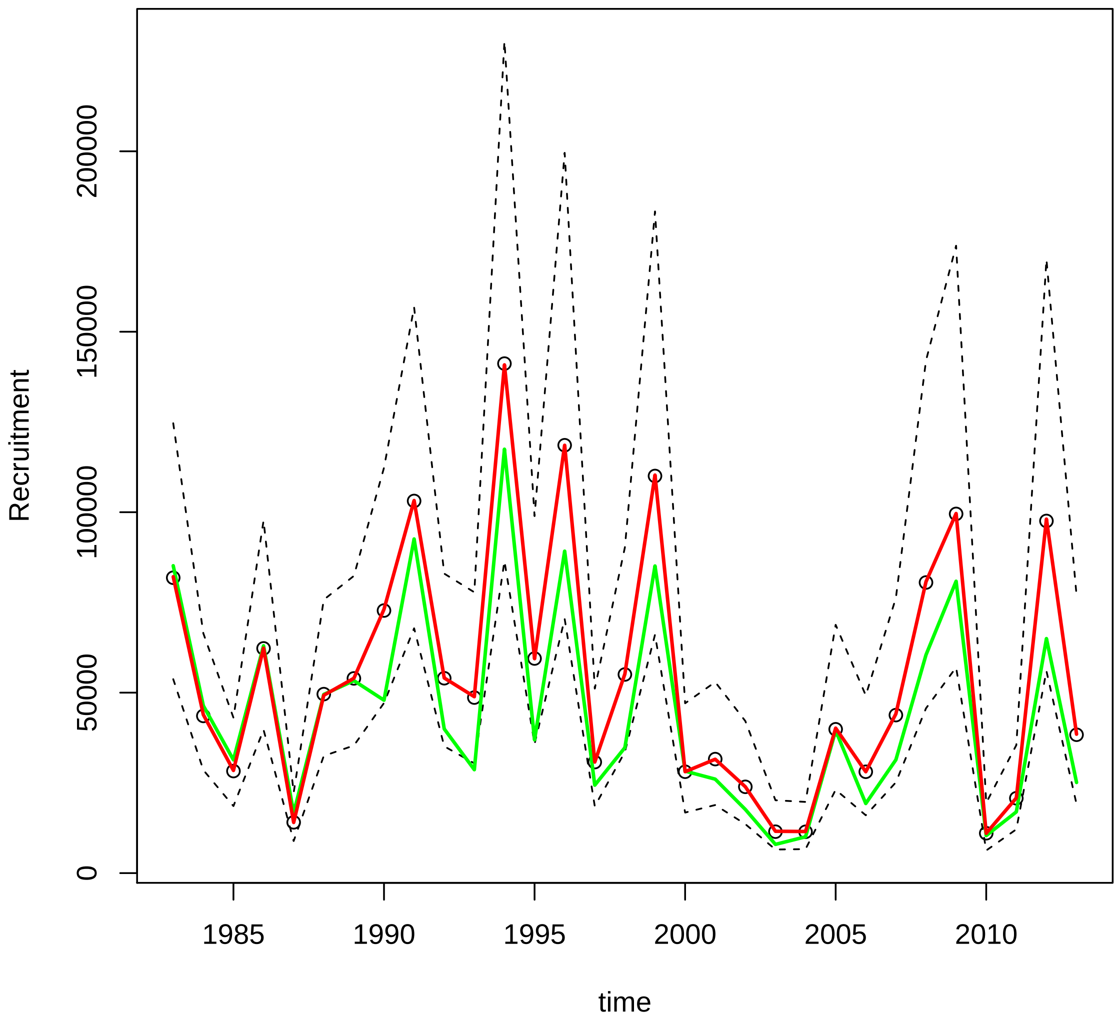


Figure 22: **Run 3** Recruitment: Black is SESAM, green is XSA, red is the base run.

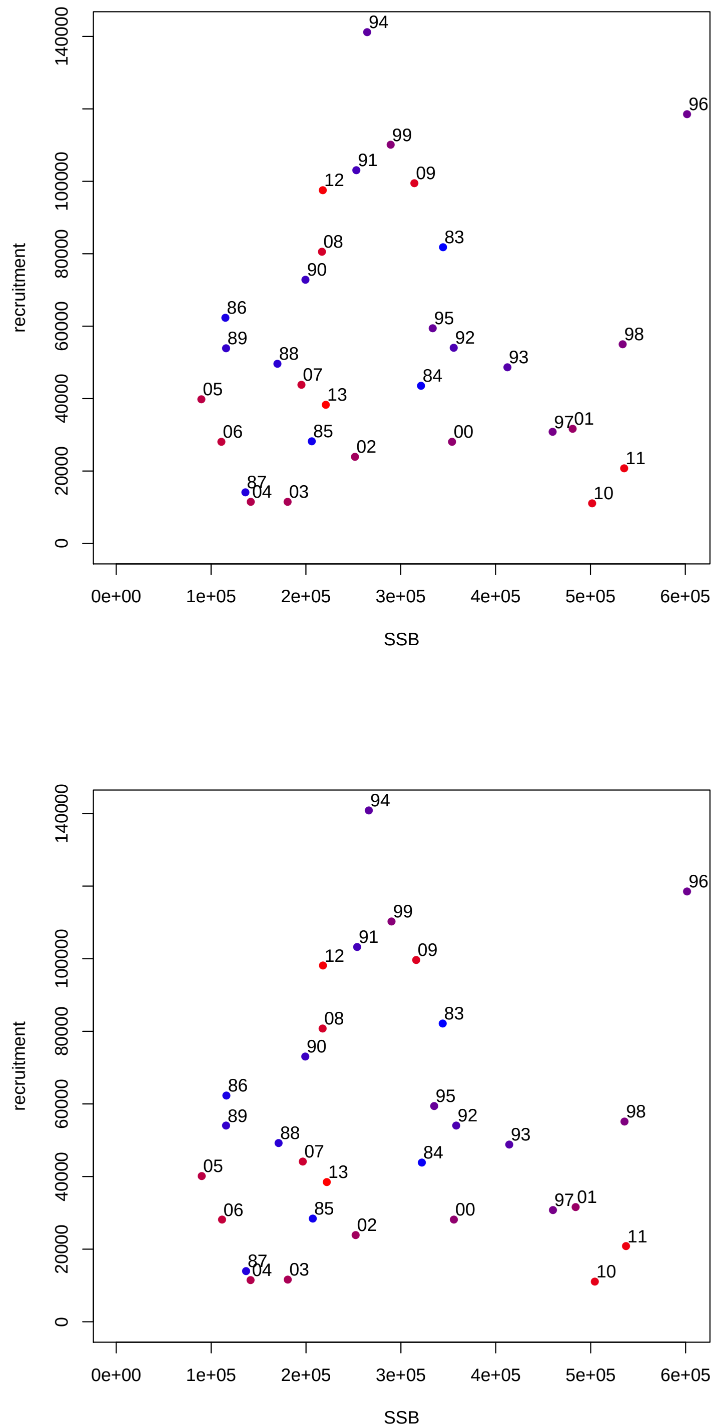


Figure 23: **Run 3** Stock-Recruitment from SESAM (top). SSB is calculated in Q1, whereas recruitment is in Q3. Bottom figure is base run.

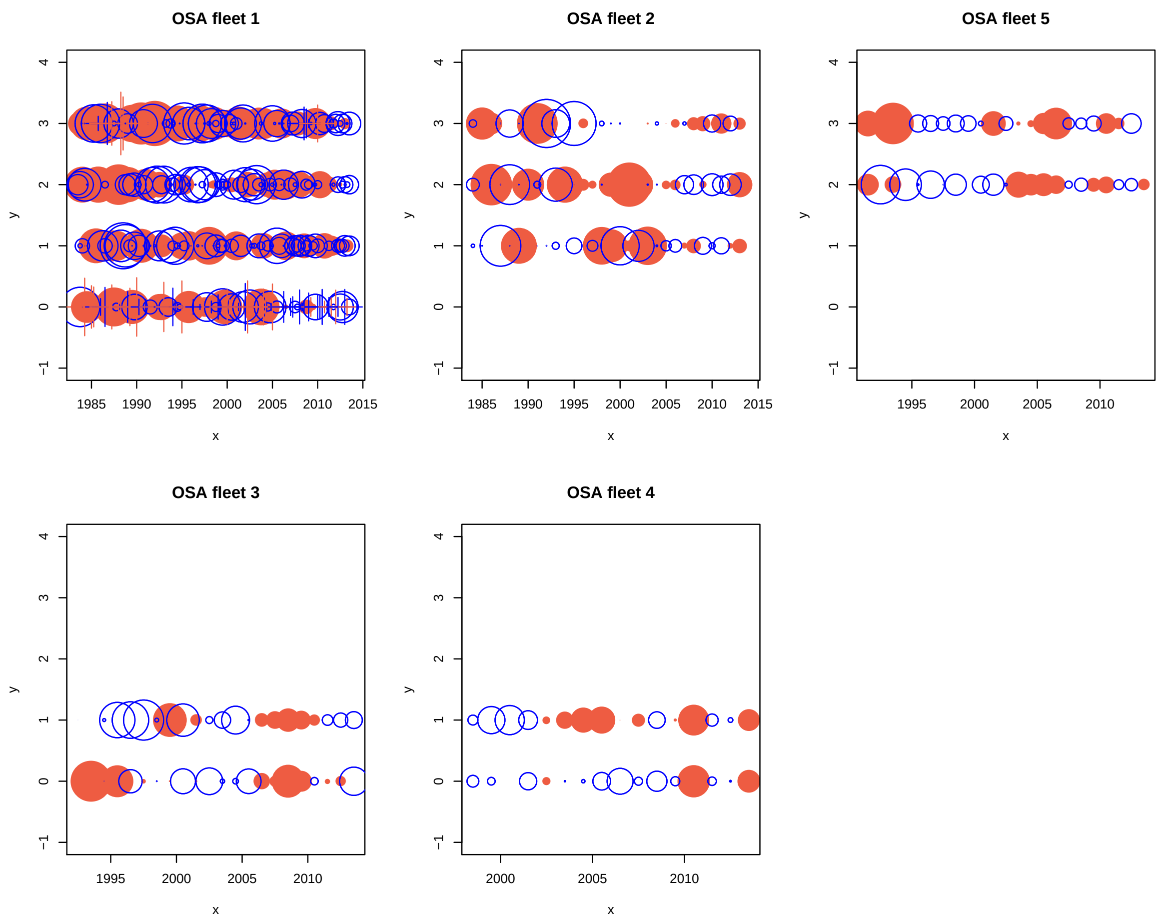


Figure 24: **Run 3** SESAM one-step ahead residuals by fleet. Circles are used for positive observations while '+' denotes randomized residuals from zero observations. Blue is positive, red is negative.

	time	SSB	lo	hi
1	1983	344.60	226.95	462.26
2	1984	321.50	219.10	423.91
3	1985	206.23	135.55	276.91
4	1986	115.14	70.96	159.32
5	1987	136.24	89.15	183.32
6	1988	170.13	93.49	246.76
7	1989	115.91	73.50	158.32
8	1990	199.63	128.66	270.61
9	1991	253.26	162.28	344.24
10	1992	355.84	228.75	482.93
11	1993	412.48	253.55	571.42
12	1994	264.73	147.18	382.29
13	1995	333.76	195.63	471.88
14	1996	601.95	331.83	872.07
15	1997	460.20	255.55	664.84
16	1998	534.14	287.17	781.11
17	1999	289.45	156.41	422.49
18	2000	354.23	202.95	505.51
19	2001	481.26	256.72	705.80
20	2002	251.79	131.89	371.68
21	2003	180.72	93.01	268.43
22	2004	141.84	72.26	211.43
23	2005	89.83	46.40	133.26
24	2006	110.93	65.15	156.71
25	2007	195.38	100.81	289.96
26	2008	216.94	121.82	312.06
27	2009	314.46	179.46	449.46
28	2010	501.84	281.11	722.57
29	2011	535.60	287.76	783.43
30	2012	217.86	119.30	316.41
31	2013	221.03	128.49	313.58
32	2014	443.54	227.63	659.44

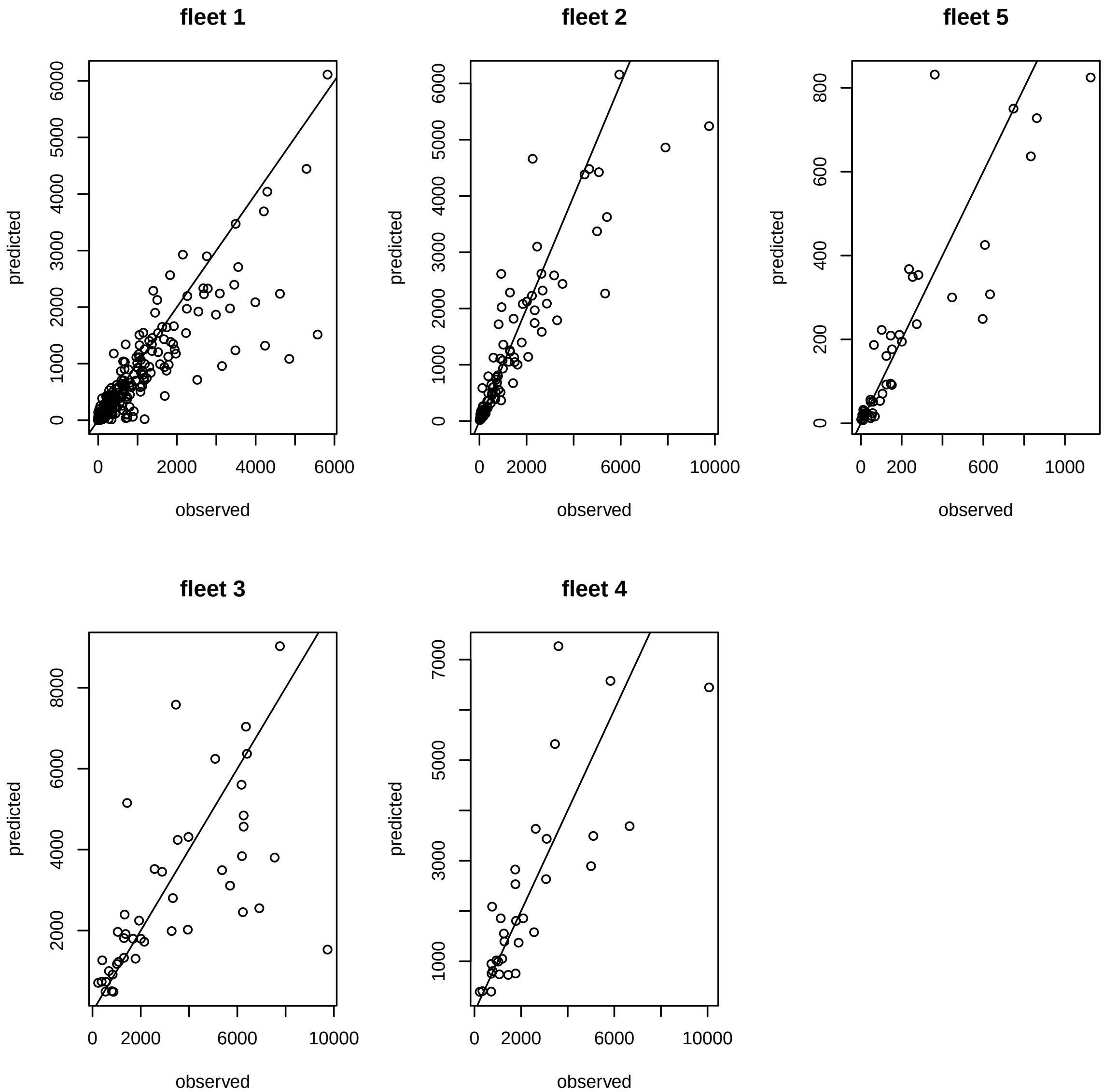
Table 10: SSB in Q1. 'lo' and 'hi' is the 5 and 95 percentiles respectively

	time	SSB	recruitment
1	1983.00	344.60	81848.02
2	1984.00	321.50	43554.70
3	1985.00	206.23	28277.63
4	1986.00	115.14	62269.37
5	1987.00	136.24	14072.29
6	1988.00	170.13	49596.43
7	1989.00	115.91	53955.75
8	1990.00	199.63	72759.58
9	1991.00	253.26	103122.05
10	1992.00	355.84	53997.57
11	1993.00	412.48	48640.16
12	1994.00	264.73	141183.70
13	1995.00	333.76	59461.80
14	1996.00	601.95	118560.57
15	1997.00	460.20	30768.31
16	1998.00	534.14	55039.21
17	1999.00	289.45	110045.44
18	2000.00	354.23	28091.56
19	2001.00	481.26	31598.33
20	2002.00	251.79	23908.13
21	2003.00	180.72	11484.36
22	2004.00	141.84	11453.13
23	2005.00	89.83	39864.04
24	2006.00	110.93	28084.87
25	2007.00	195.38	43788.01
26	2008.00	216.94	80530.41
27	2009.00	314.46	99534.67
28	2010.00	501.84	11048.35
29	2011.00	535.60	20742.33
30	2012.00	217.86	97577.68
31	2013.00	221.03	38345.32

Table 11: Estimated SSB in Q1 and recruitment in Q3

	time	fbar	fbar5	ssb	ssb5
1	2014.25	0.04	0.02	317.19	194.97
2	2014.50	0.15	0.07	349.73	214.78
3	2014.75	0.62	0.27	228.09	136.44
4	2015.00	0.00	0.00	283.33	168.03
5	2015.25	0.04	0.02	221.60	131.16
6	2015.50	0.15	0.07	231.01	132.03
7	2015.75	0.62	0.27	151.54	83.94
8	2016.00	0.00	0.00	235.15	112.40

Table 12: Forecast given status quo F. 'fbar5' and 'ssb5' are the 5th percentiles



[!htb]

Figure 25: **Run 3** Observed versus predicted.

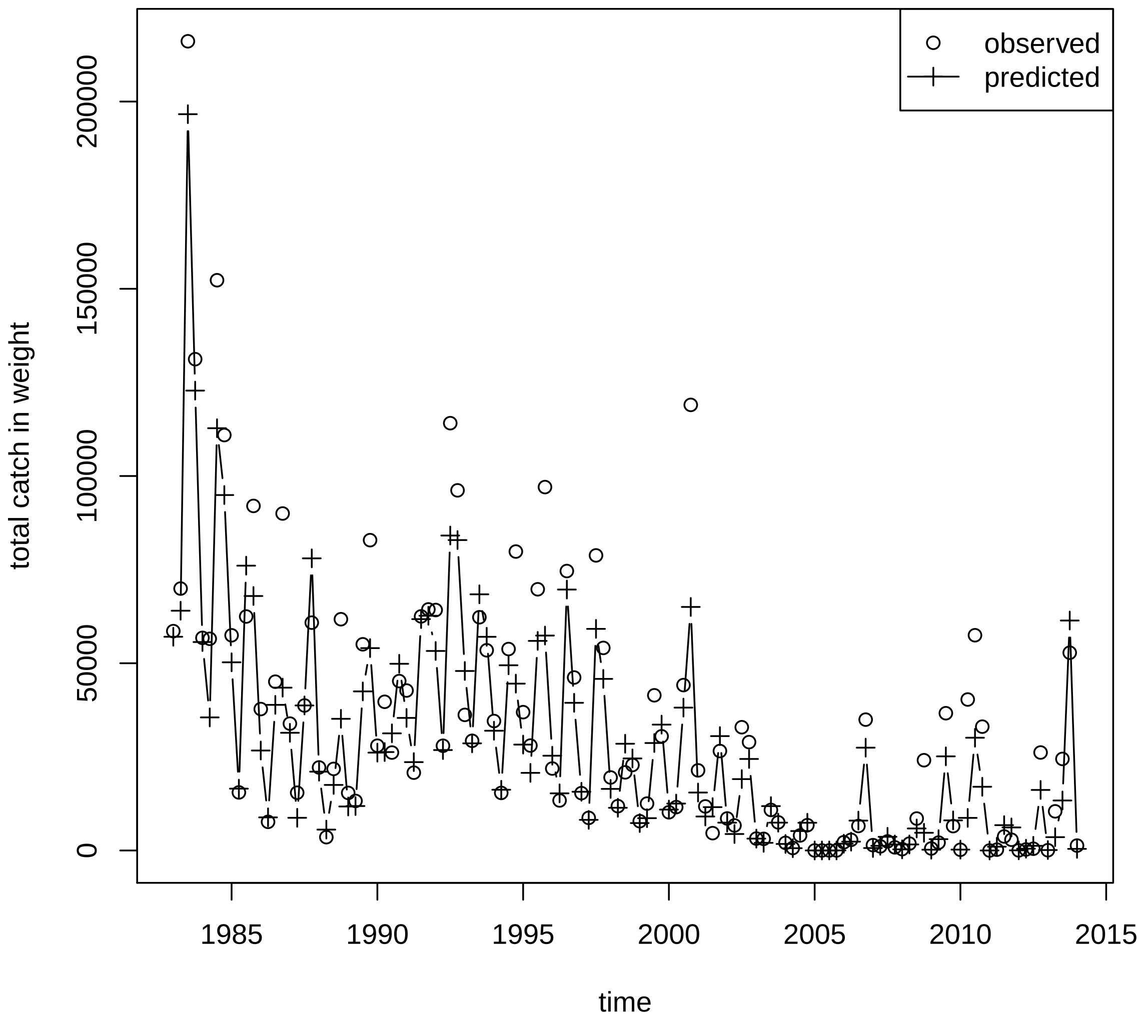


Figure 26: Total catch weight observed versus predicted by quarter.

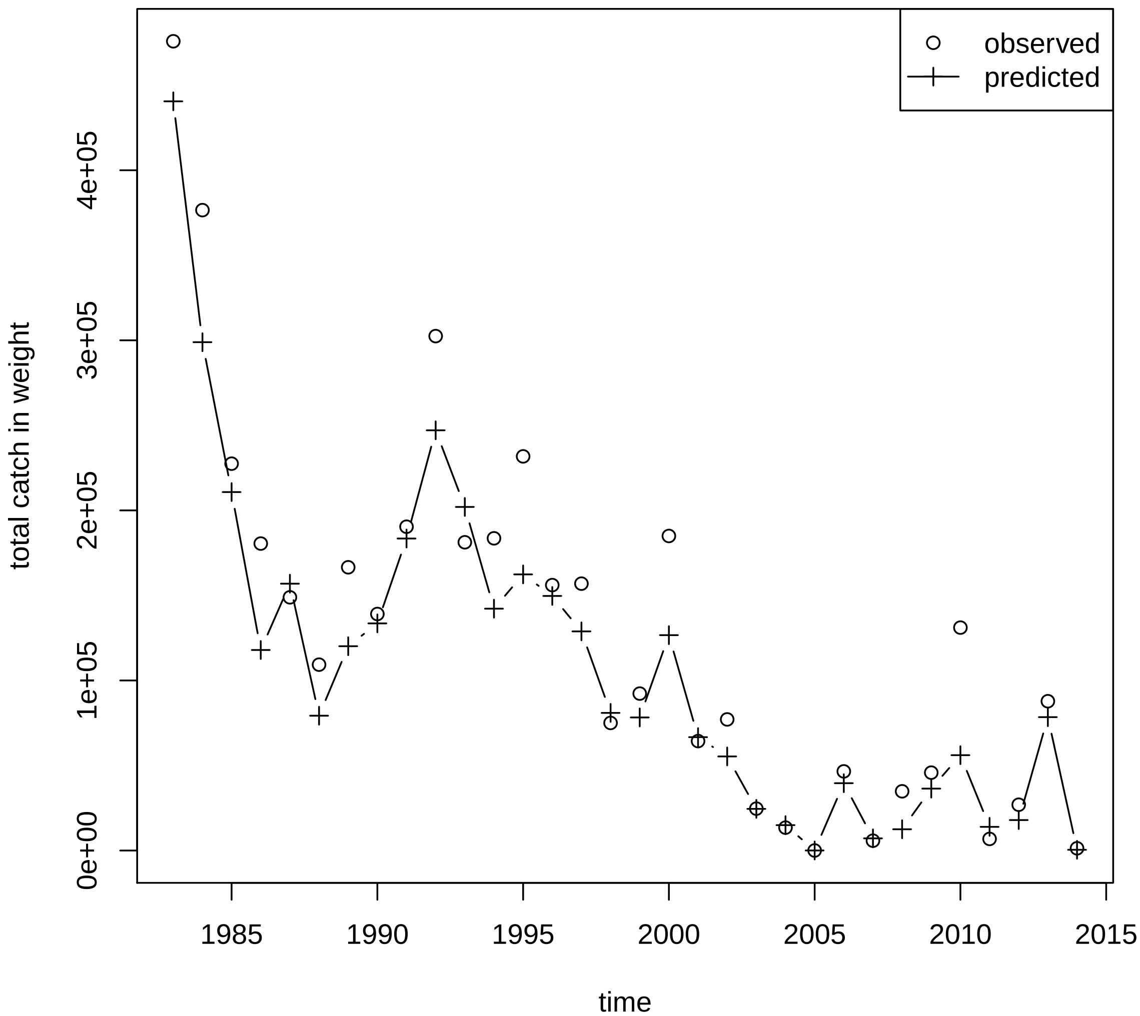


Figure 27: Total catch weight observed versus predicted by year.

	time	fbar	fbar5.0	ssb	ssb5
1	2014.25	0.00	0.00	317.47	195.22
2	2014.50	0.00	0.00	355.45	219.91
3	2014.75	0.00	0.00	244.33	151.55
4	2015.00	0.00	0.00	335.26	216.60
5	2015.25	0.00	0.00	261.38	167.48
6	2015.50	0.00	0.00	275.90	170.59
7	2015.75	0.00	0.00	187.84	114.35
8	2016.00	0.00	0.00	315.18	154.51

Table 13: Forecast given zero F. 'fbar5' and 'ssb5' are the 5th percentiles

Parameter estimates

```
                Estimate   Std. Error
logSdLogFsta -0.40624157 1.796872e-01
logSdLogN    -4.00000000 1.956329e+01
logSdLogObs   0.83091188 6.221925e-02
logSdLogObs  -0.37694370 9.014096e-02
logSdLogObs  -0.63408005 8.696643e-02
logSdLogObs  -0.50634609 1.155941e-01
logSdLogObs  -0.77300383 1.423206e-01
logSdLogObs  -0.41923205 1.159904e-01
logQ         -2.37617512 1.985583e-01
logQ         -1.81340178 2.314981e-01
logQ         -1.82329535 3.383826e-01
logQ         -2.57486680 2.421594e-01
logQ         -1.78473301 2.489217e-01
logQ         -2.49939687 2.472203e-01
logQ         -1.94878754 2.537791e-01
logQ         -1.90717641 2.958024e-01
logQ         -2.75852047 3.609283e-01
trans_rho     5.32732309 4.457078e-01
logSdLogR    -0.08026687 1.436576e-01
rho           0.99995282 4.205675e-05
```

3.4 Run 4

In run 4 the detection limit has been set to 2 times the smallest observation greater than zero by fleet.

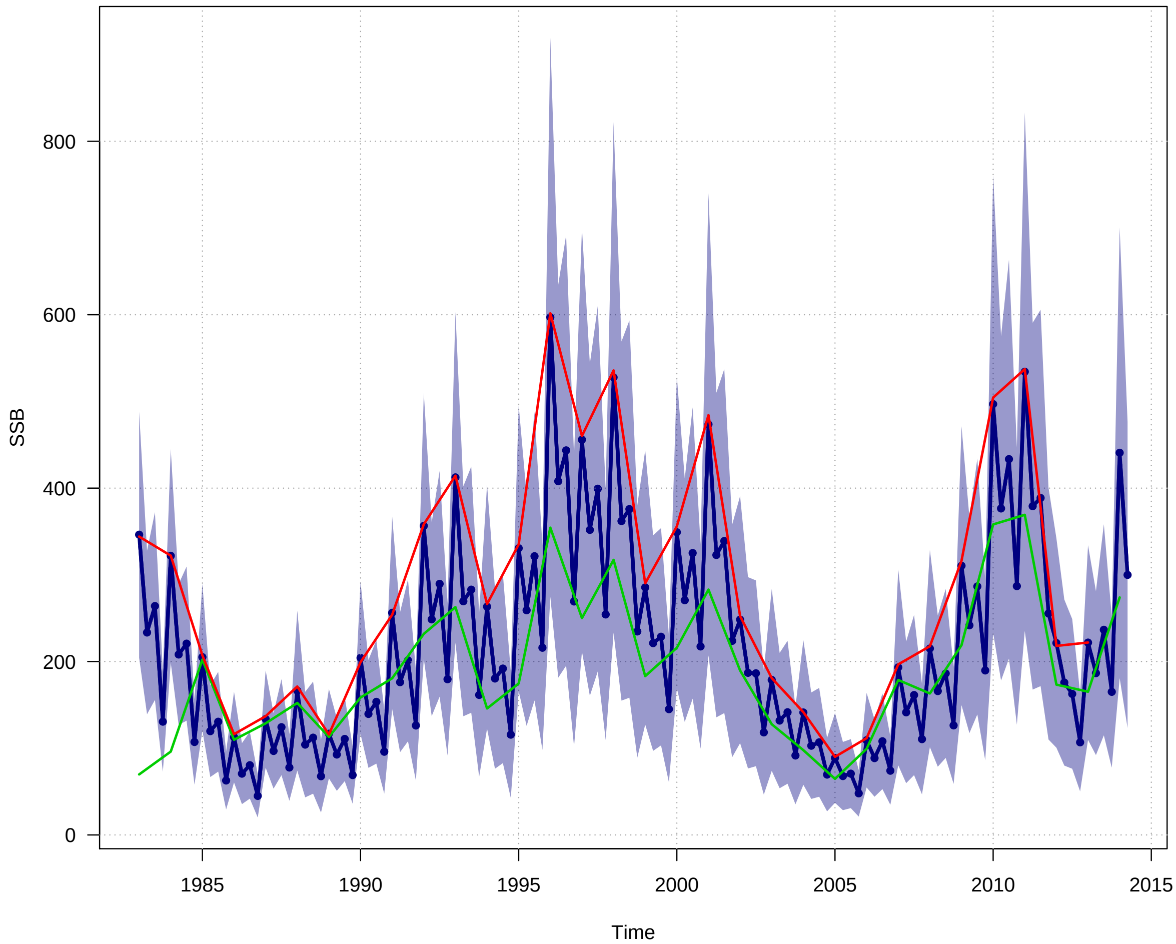


Figure 28: **Run 4** SSB: Blue is SESAM, green is XSA (May 2014), red is the base run.

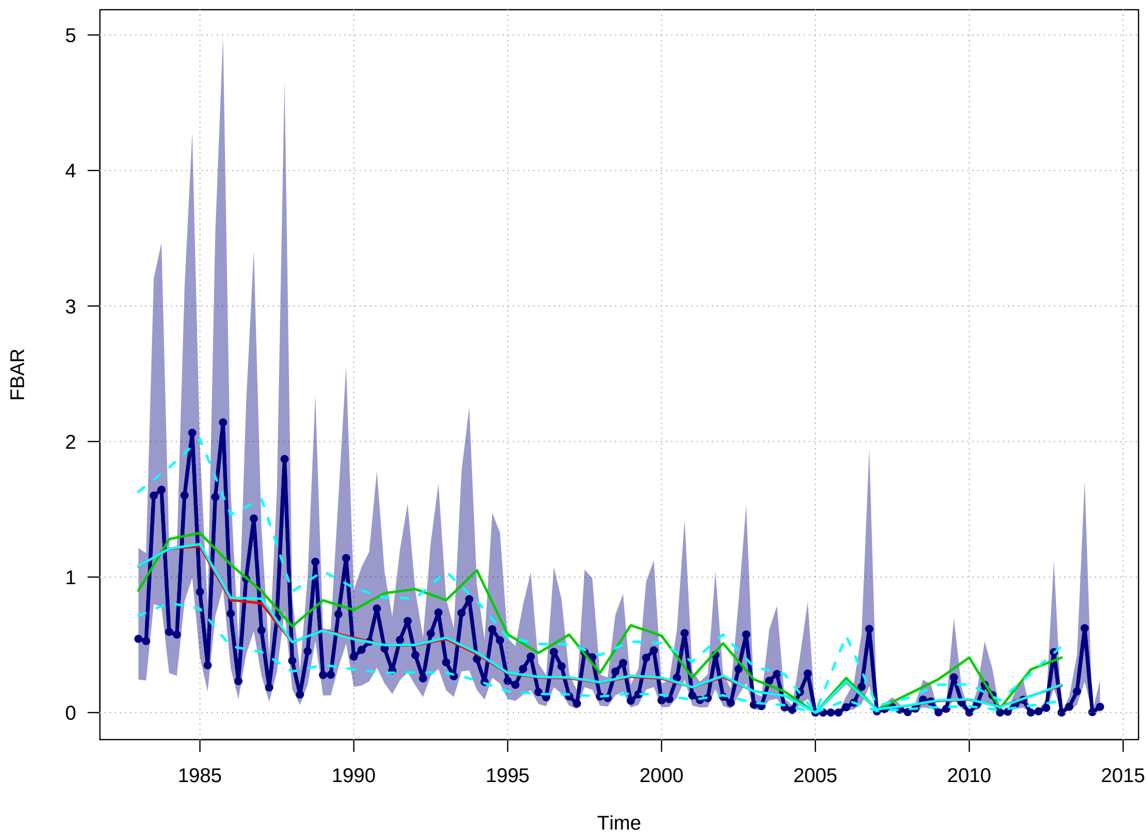


Figure 29: **Run 4** $\bar{F}_{1-2}$: Blue is SESAM by quarter, cyan is SESAM yearly average, green is XSA yearly average, red is the base run.

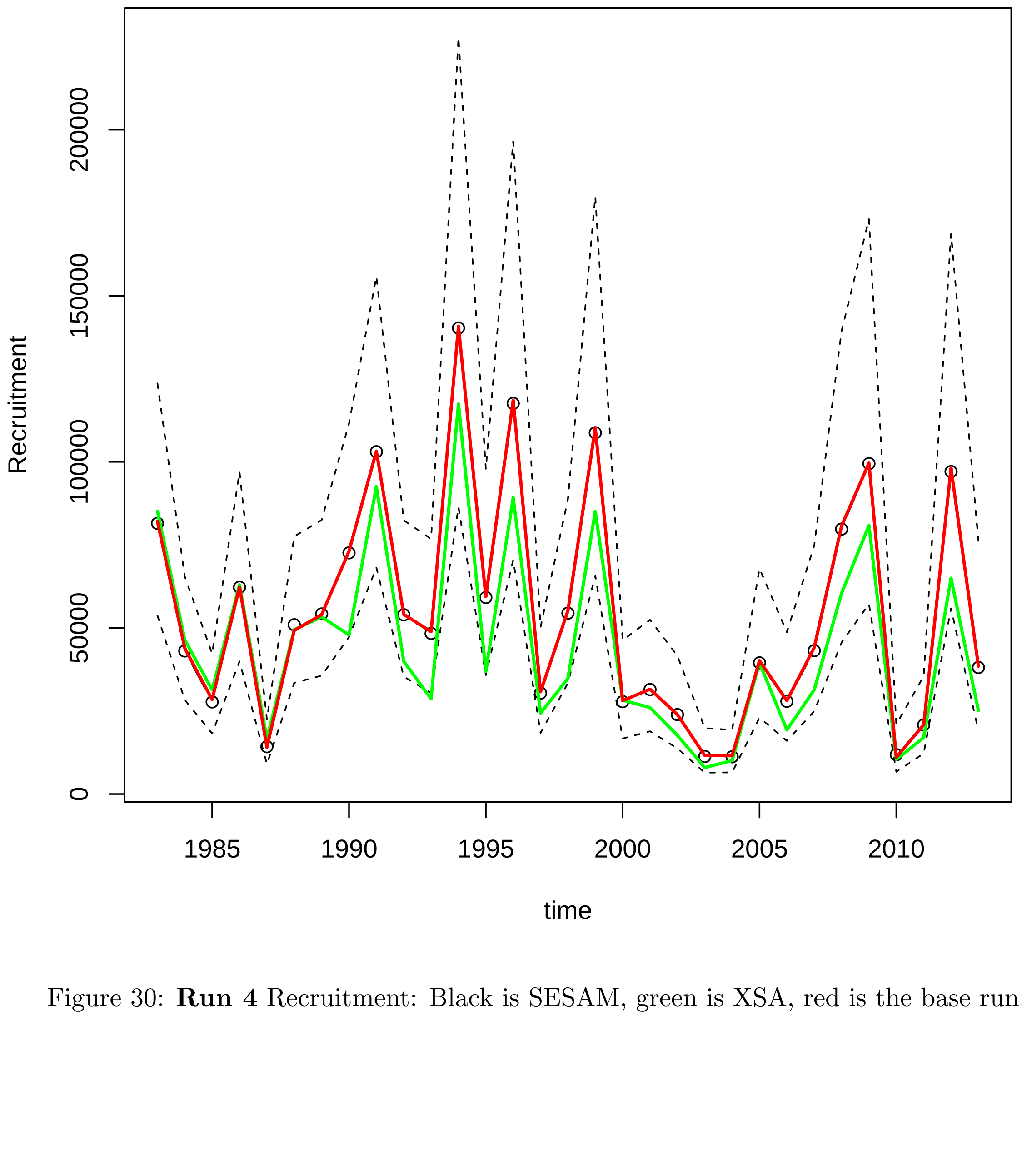
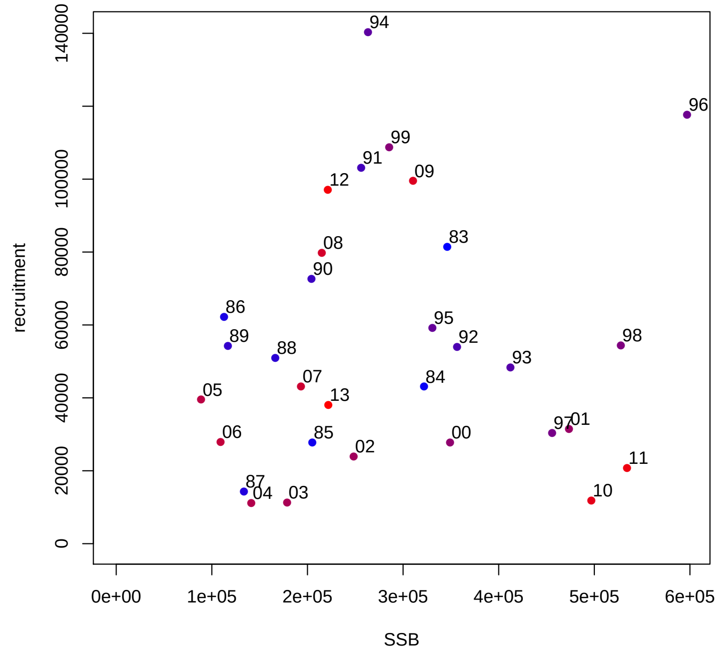


Figure 30: **Run 4** Recruitment: Black is SESAM, green is XSA, red is the base run.



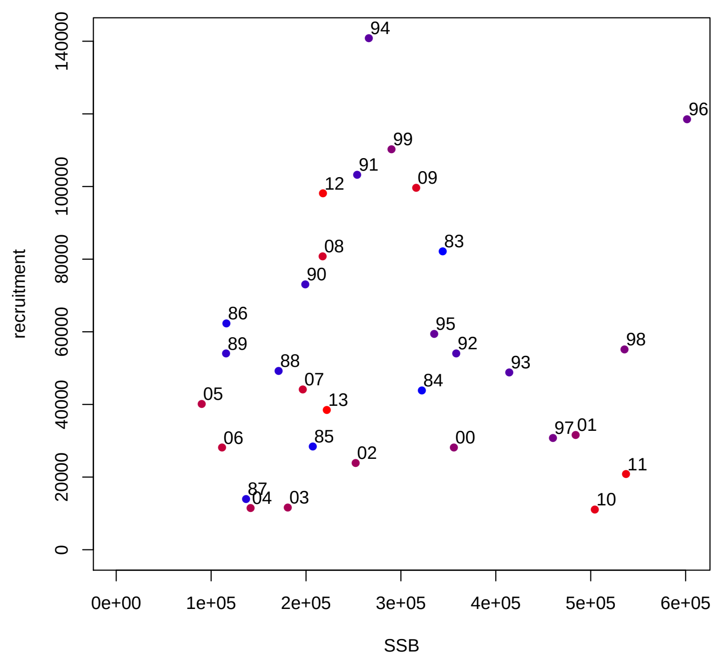


Figure 31: **Run 4** Stock-Recruitment from SESAM (top). SSB is calculated in Q1, whereas recruitment is in Q3. Bottom figure is base run.

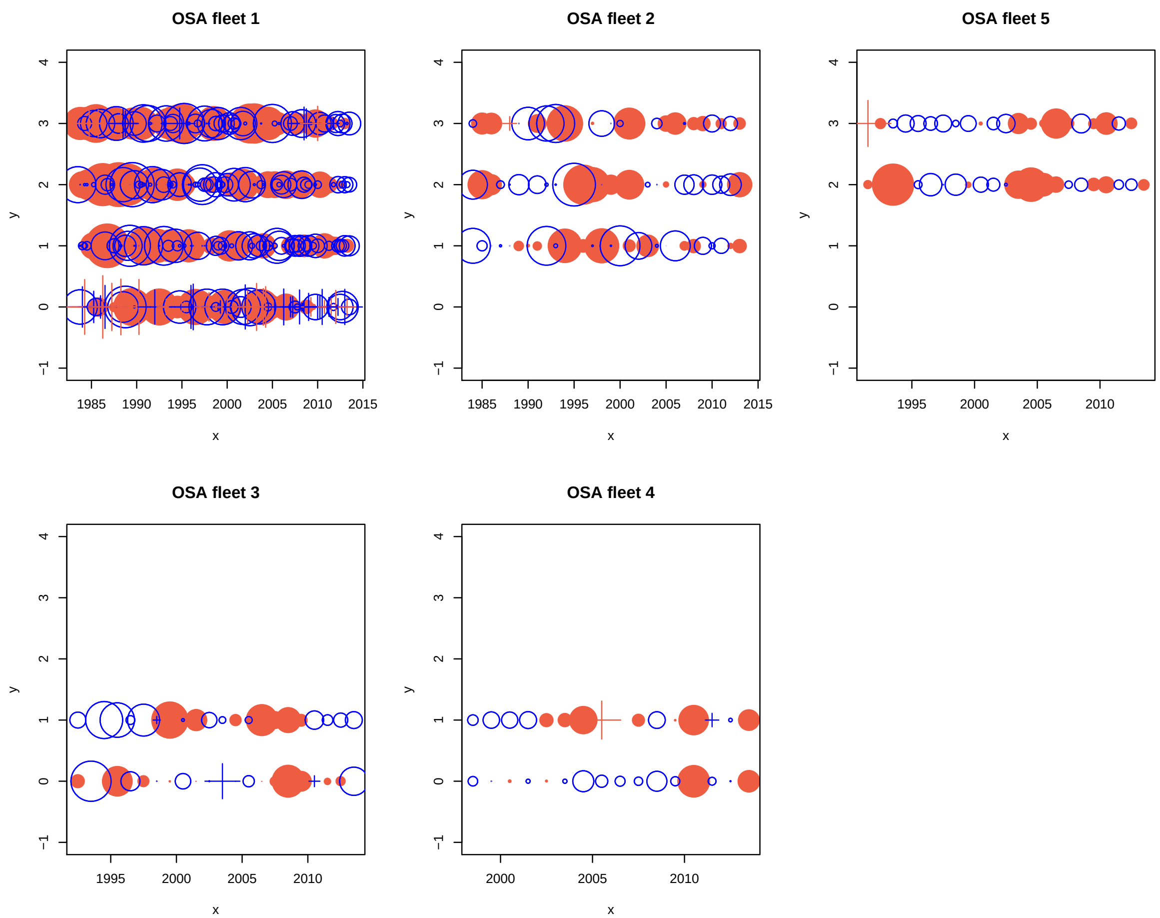


Figure 32: **Run 4** SESAM one-step ahead residuals by fleet. Circles are used for positive observations while '+' denotes randomized residuals from zero observations. Blue is positive, red is negative.

	time	SSB	lo	hi
1	1983	346.32	229.51	463.14
2	1984	321.96	220.55	423.37
3	1985	205.07	135.47	274.67
4	1986	112.85	69.84	155.85
5	1987	133.69	87.53	179.85
6	1988	166.44	90.58	242.29
7	1989	116.80	74.41	159.20
8	1990	204.21	131.93	276.49
9	1991	256.24	164.93	347.55
10	1992	356.52	230.30	482.74
11	1993	412.40	255.56	569.24
12	1994	263.33	147.60	379.06
13	1995	330.71	195.11	466.31
14	1996	597.07	331.90	862.24
15	1997	455.91	255.01	656.82
16	1998	527.75	285.56	769.95
17	1999	285.50	155.42	415.58
18	2000	349.11	201.24	496.99
19	2001	473.56	254.36	692.76
20	2002	248.39	131.16	365.61
21	2003	178.80	92.55	265.06
22	2004	141.25	72.65	209.85
23	2005	88.83	46.23	131.43
24	2006	109.26	64.40	154.12
25	2007	193.31	100.39	286.24
26	2008	215.02	121.47	308.58
27	2009	310.49	178.19	442.79
28	2010	496.93	279.78	714.08
29	2011	534.26	288.36	780.17
30	2012	221.39	122.08	320.69
31	2013	221.86	129.51	314.22
32	2014	440.79	227.03	654.55

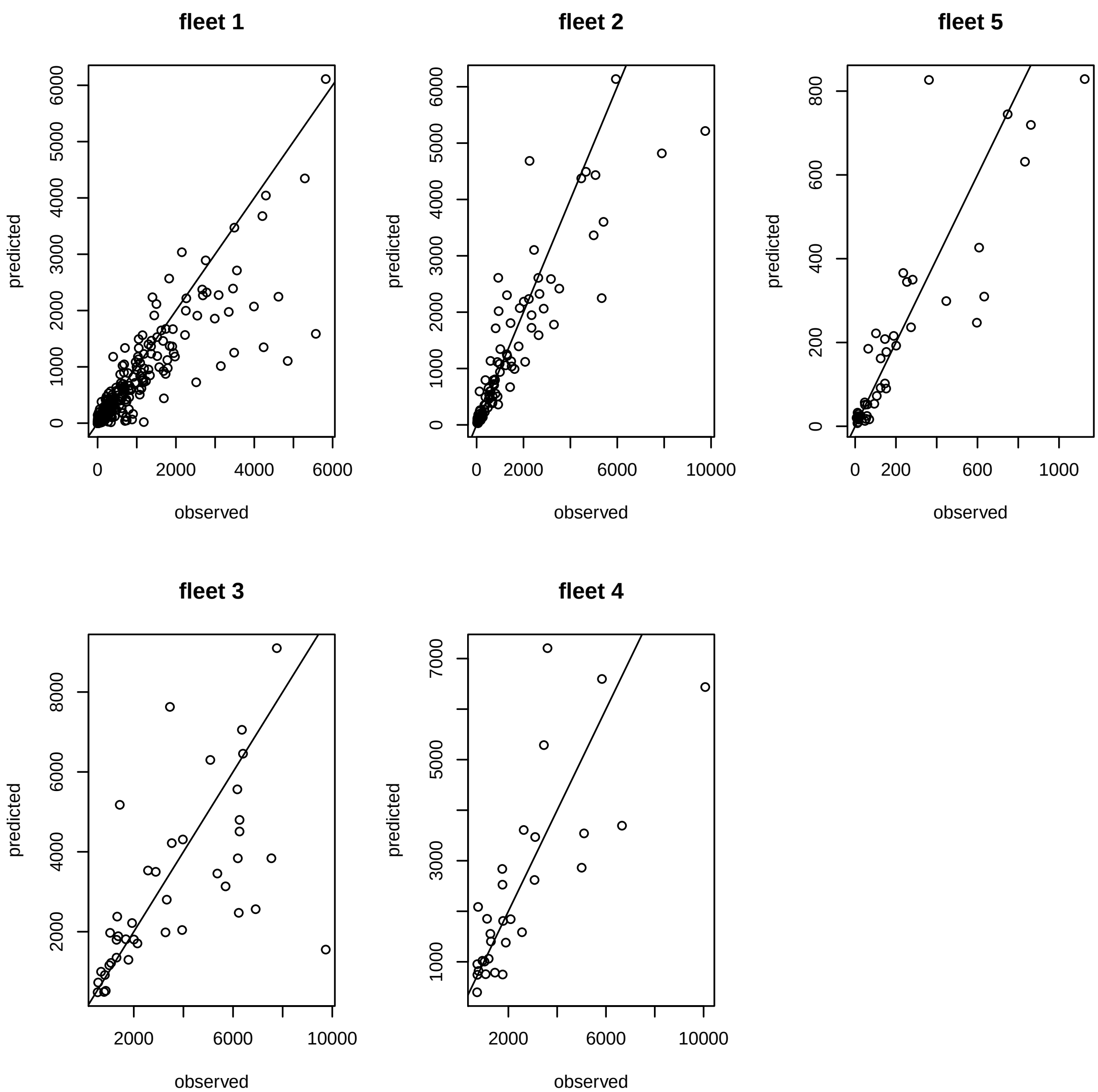
Table 14: SSB in Q1. 'lo' and 'hi' is the 5 and 95 percentiles respectively

	time	SSB	recruitment
1	1983.00	346.32	81495.78
2	1984.00	321.96	43066.39
3	1985.00	205.07	27730.58
4	1986.00	112.85	62251.03
5	1987.00	133.69	14250.51
6	1988.00	166.44	50963.98
7	1989.00	116.80	54212.13
8	1990.00	204.21	72599.37
9	1991.00	256.24	103064.15
10	1992.00	356.52	53958.81
11	1993.00	412.40	48355.08
12	1994.00	263.33	140309.88
13	1995.00	330.71	59167.78
14	1996.00	597.07	117611.18
15	1997.00	455.91	30394.37
16	1998.00	527.75	54447.13
17	1999.00	285.50	108754.62
18	2000.00	349.11	27811.47
19	2001.00	473.56	31468.24
20	2002.00	248.39	23922.28
21	2003.00	178.80	11300.67
22	2004.00	141.25	11211.74
23	2005.00	88.83	39500.27
24	2006.00	109.26	27913.18
25	2007.00	193.31	43164.77
26	2008.00	215.02	79748.84
27	2009.00	310.49	99483.78
28	2010.00	496.93	11843.53
29	2011.00	534.26	20809.44
30	2012.00	221.39	97072.00
31	2013.00	221.86	38095.74

Table 15: Estimated SSB in Q1 and recruitment in Q3

	time	fbar	fbar5	ssb	ssb5
1	2014.25	0.04	0.02	314.87	194.48
2	2014.50	0.16	0.07	346.98	212.74
3	2014.75	0.63	0.28	225.80	134.14
4	2015.00	0.00	0.00	280.50	164.45
5	2015.25	0.04	0.02	220.28	129.18
6	2015.50	0.16	0.07	227.99	129.24
7	2015.75	0.63	0.28	149.68	83.05
8	2016.00	0.00	0.00	231.97	110.28

Table 16: Forecast given status quo F. 'fbar5' and 'ssb5' are the 5th percentiles



[!htb]

Figure 33: **Run 4** Observed versus predicted.

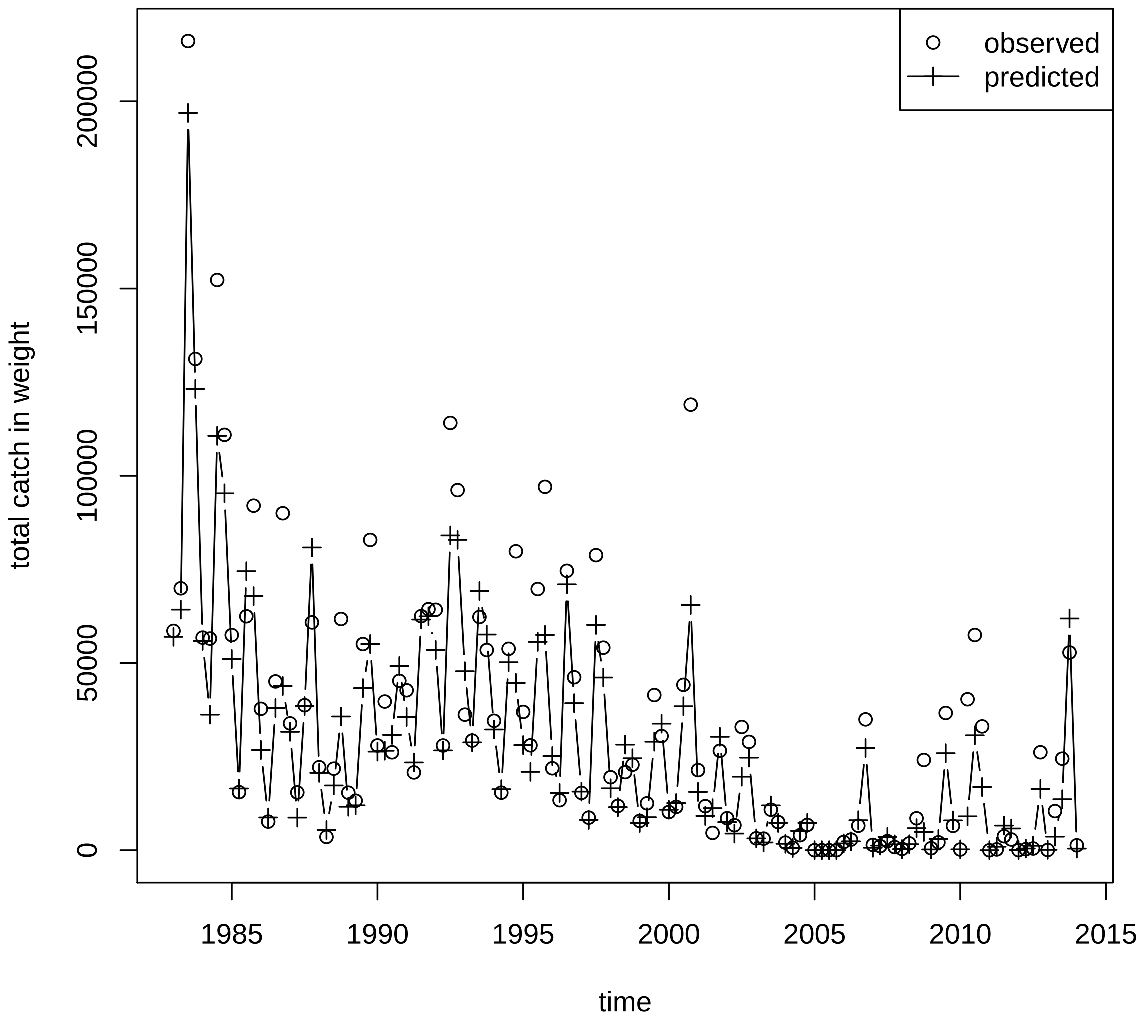


Figure 34: Total catch weight observed versus predicted by quarter.

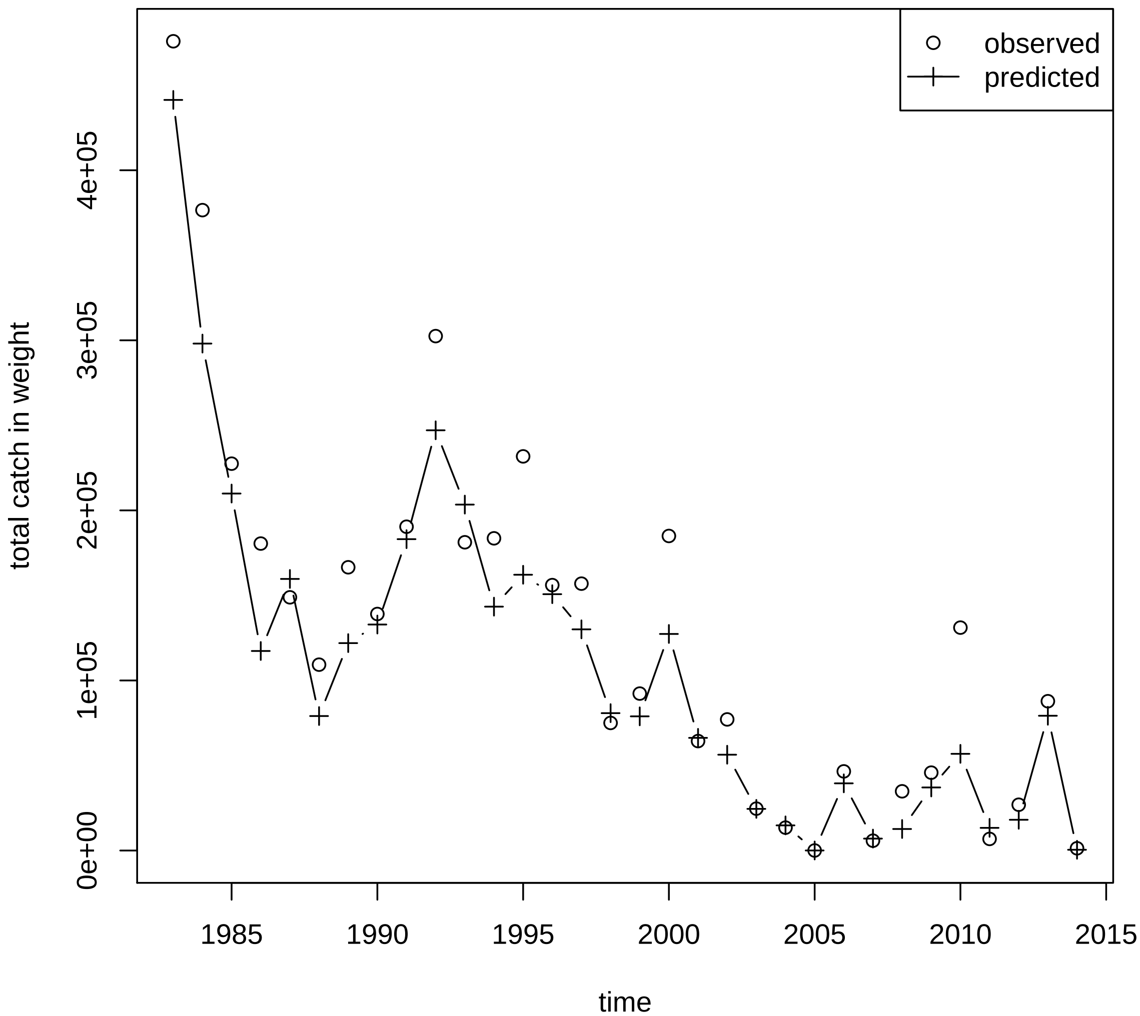


Figure 35: Total catch weight observed versus predicted by year.

	time	fbar	fbar5.0	ssb	ssb5
1	2014.25	0.00	0.00	315.26	194.78
2	2014.50	0.00	0.00	353.00	218.20
3	2014.75	0.00	0.00	242.75	149.69
4	2015.00	0.00	0.00	333.59	212.66
5	2015.25	0.00	0.00	259.06	165.03
6	2015.50	0.00	0.00	273.21	167.66
7	2015.75	0.00	0.00	185.68	112.57
8	2016.00	0.00	0.00	313.94	154.24

Table 17: Forecast given zero F. 'fbar5' and 'ssb5' are the 5th percentiles

Parameter estimates

```
               Estimate   Std. Error
logSdLogFsta -0.37770275 1.681664e-01
logSdLogN    -4.00000000 1.658156e+01
logSdLogObs   0.76063278 6.278404e-02
logSdLogObs  -0.38786445 8.778245e-02
logSdLogObs  -0.62631197 8.757709e-02
logSdLogObs  -0.50816782 1.213752e-01
logSdLogObs  -0.78069255 1.492233e-01
logSdLogObs  -0.44677772 1.188929e-01
logQ         -2.37289475 1.971866e-01
logQ         -1.80894355 2.297644e-01
logQ         -1.81836753 3.364211e-01
logQ         -2.56082972 2.407735e-01
logQ         -1.78466188 2.473499e-01
logQ         -2.49594937 2.451722e-01
logQ         -1.93409557 2.528644e-01
logQ         -1.90154842 2.921039e-01
logQ         -2.73142915 3.579847e-01
trans_rho     5.37241235 4.278246e-01
logSdLogR    -0.08646003 1.437117e-01
rho           0.99995689 3.688833e-05
```

3.5 Run 5

In run 5 the two first years of data (1983 and 1984) have been omitted.

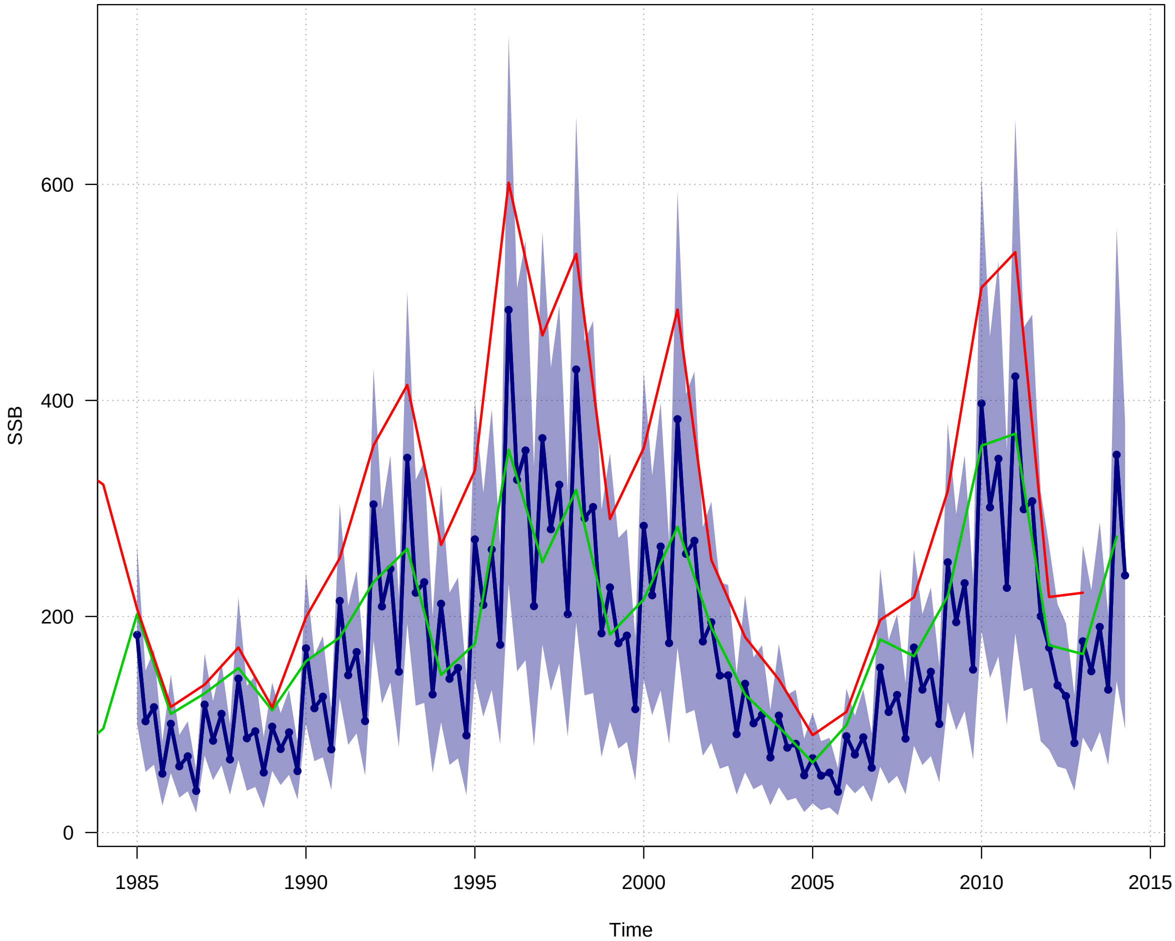


Figure 36: **run 5** SSB: Blue is SESAM, green is XSA (May 2014), red is the base run.

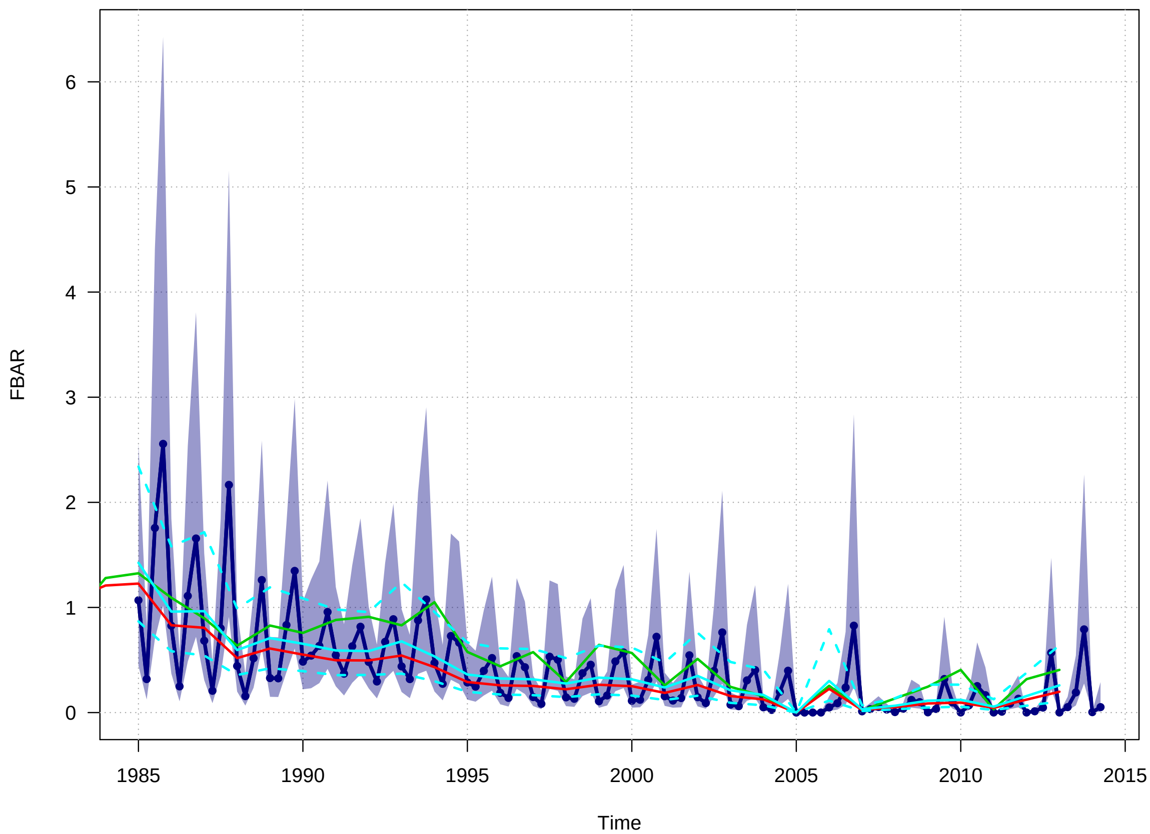


Figure 37: **run 5** $\bar{F}_{1-2}$: Blue is SESAM by quarter, cyan is SESAM yearly average, green is XSA yearly average, red is the base run.

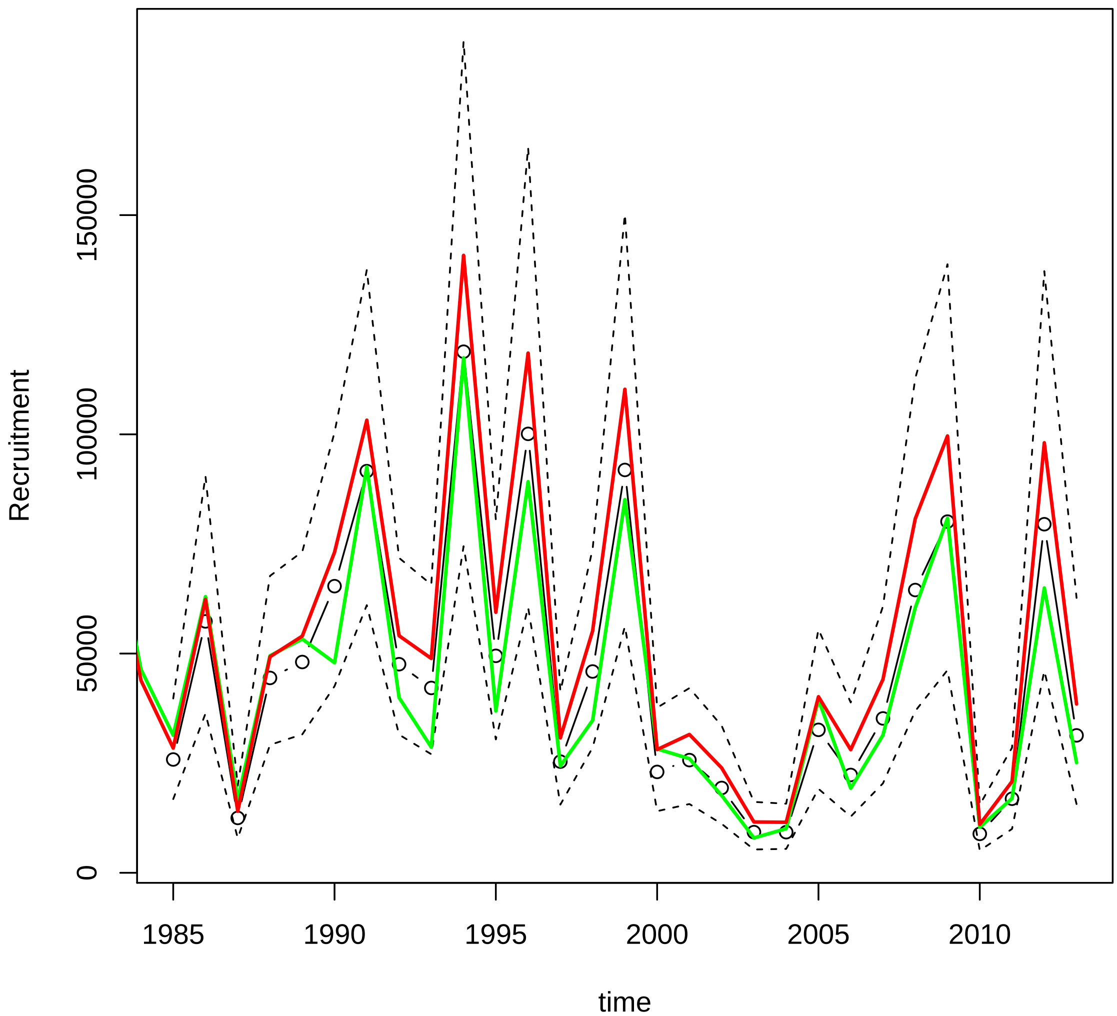


Figure 38: **run 5** Recruitment: Black is SESAM, green is XSA, red is the base run.

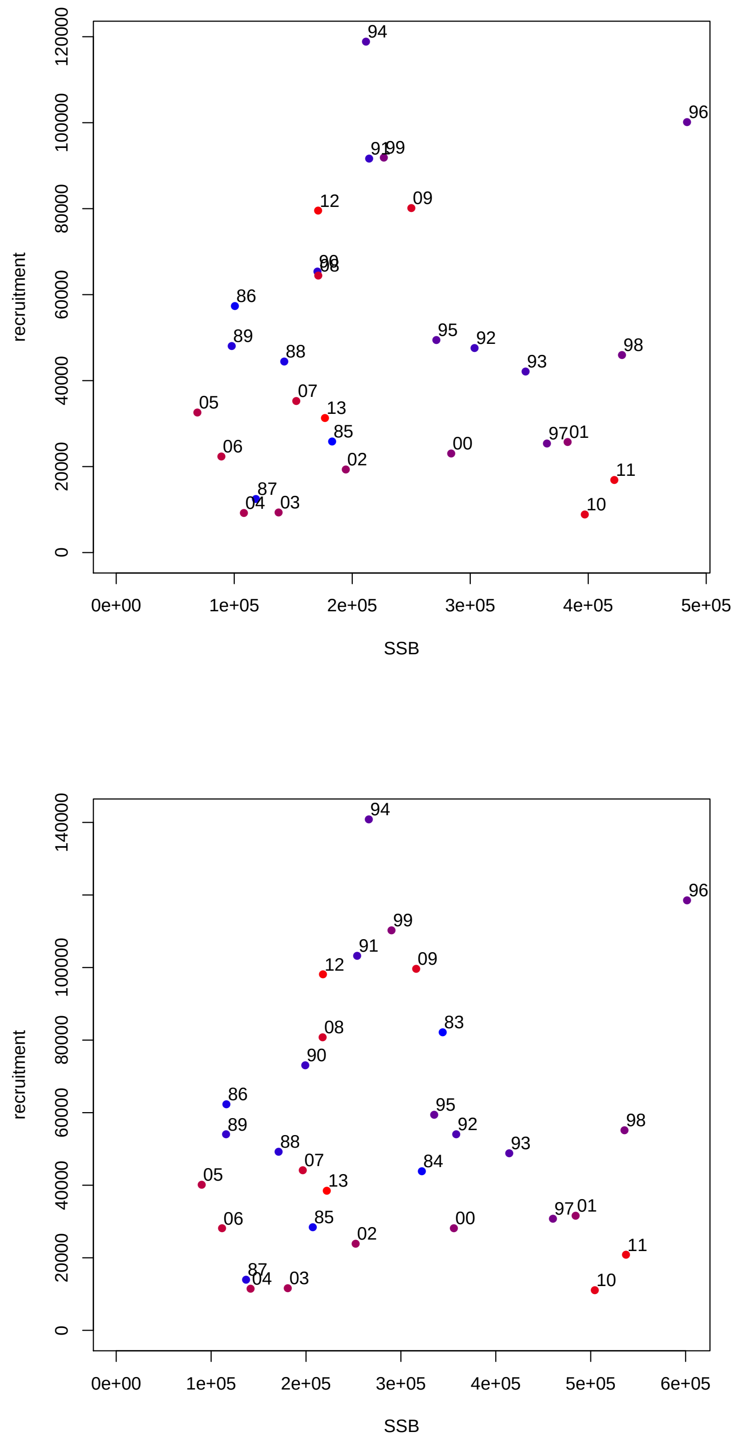


Figure 39: **run 5** Stock-Recruitment from SESAM (top). SSB is calculated in Q1, whereas recruitment is in Q3. Bottom figure is base run.

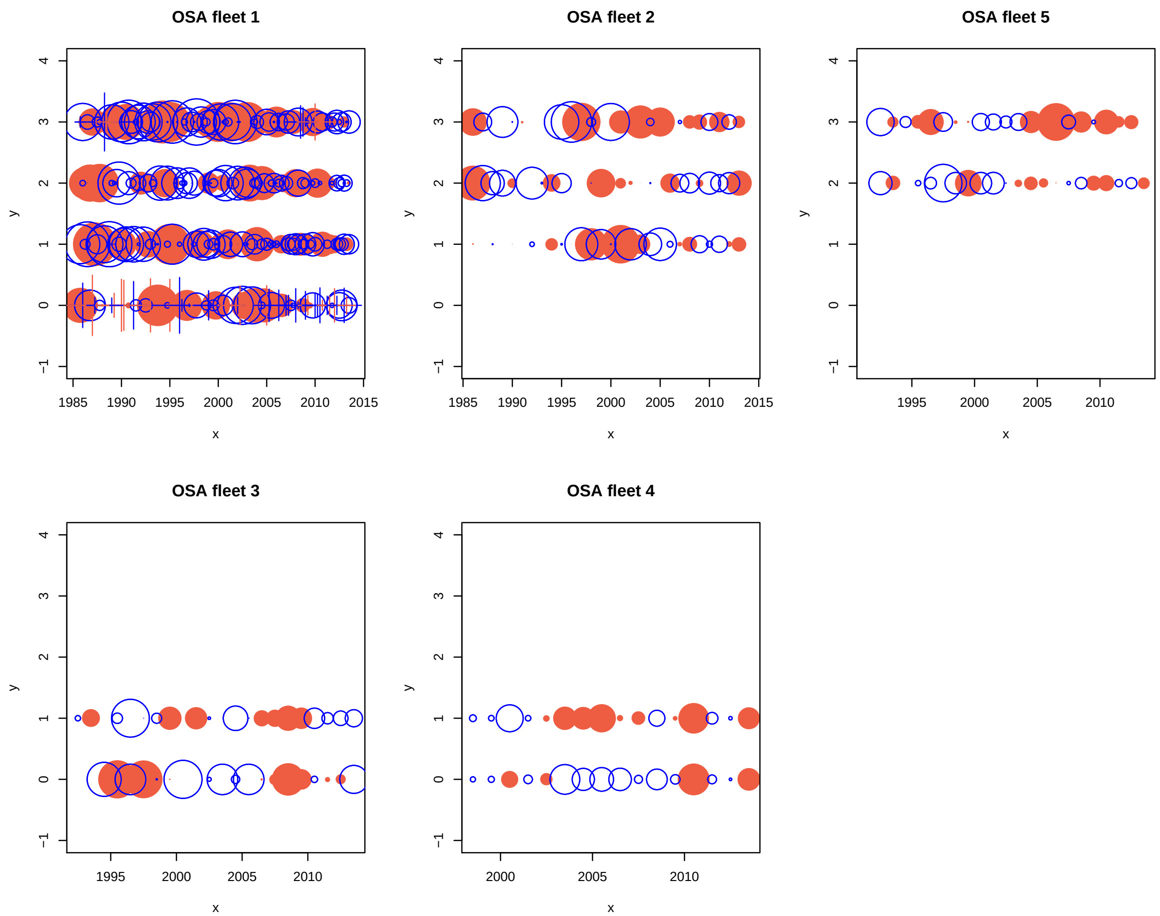


Figure 40: **run 5** SESAM one-step ahead residuals by fleet. Circles are used for positive observations while '+' denotes randomized residuals from zero observations. Blue is positive, red is negative.

	time	SSB	lo	hi
1	1985	182.98	114.79	251.18
2	1986	100.65	63.11	138.19
3	1987	118.43	79.52	157.34
4	1988	142.49	80.58	204.40
5	1989	97.97	64.30	131.64
6	1990	170.55	112.78	228.32
7	1991	214.41	140.42	288.40
8	1992	303.78	200.24	407.32
9	1993	346.94	220.65	473.24
10	1994	211.75	121.61	301.88
11	1995	271.34	165.50	377.18
12	1996	483.82	275.13	692.50
13	1997	365.09	208.02	522.17
14	1998	428.64	235.89	621.40
15	1999	226.91	124.76	329.07
16	2000	283.96	166.83	401.09
17	2001	382.67	208.89	556.45
18	2002	194.62	102.81	286.42
19	2003	137.69	70.21	205.16
20	2004	108.22	53.62	162.82
21	2005	68.87	34.30	103.43
22	2006	89.16	53.00	125.31
23	2007	152.69	77.15	228.24
24	2008	171.25	96.38	246.11
25	2009	250.16	143.88	356.45
26	2010	397.19	224.10	570.28
27	2011	422.23	226.62	617.84
28	2012	171.19	93.37	249.02
29	2013	177.00	103.84	250.16
30	2014	349.72	177.42	522.02

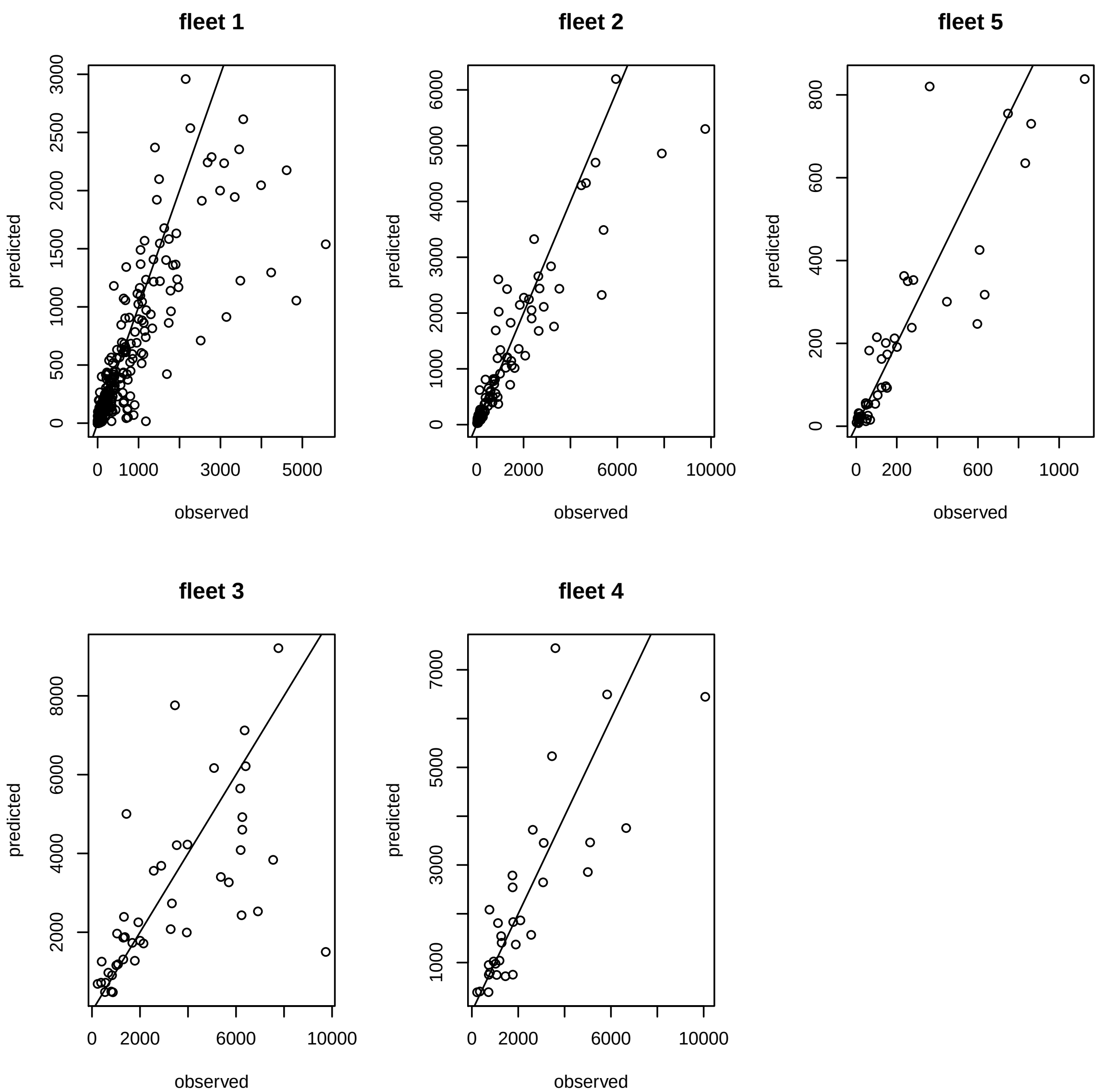
Table 18: SSB in Q1. 'lo' and 'hi' is the 5 and 95 percentiles respectively

	time	SSB	recruitment
1	1985.00	182.98	25847.09
2	1986.00	100.65	57336.91
3	1987.00	118.43	12514.27
4	1988.00	142.49	44448.52
5	1989.00	97.97	48078.90
6	1990.00	170.55	65375.07
7	1991.00	214.41	91612.04
8	1992.00	303.78	47572.04
9	1993.00	346.94	42158.93
10	1994.00	211.75	118852.49
11	1995.00	271.34	49487.13
12	1996.00	483.82	100109.01
13	1997.00	365.09	25360.56
14	1998.00	428.64	45918.93
15	1999.00	226.91	91881.25
16	2000.00	283.96	23014.17
17	2001.00	382.67	25704.23
18	2002.00	194.62	19350.92
19	2003.00	137.69	9277.10
20	2004.00	108.22	9265.02
21	2005.00	68.87	32607.05
22	2006.00	89.16	22317.29
23	2007.00	152.69	35212.32
24	2008.00	171.25	64495.92
25	2009.00	250.16	80103.32
26	2010.00	397.19	8882.67
27	2011.00	422.23	16892.38
28	2012.00	171.19	79504.88
29	2013.00	177.00	31345.86

Table 19: Estimated SSB in Q1 and recruitment in Q3

	time	fbar	fbar5	ssb	ssb5
1	2014.25	0.05	0.02	250.98	153.83
2	2014.50	0.20	0.08	277.54	168.83
3	2014.75	0.81	0.34	178.31	104.57
4	2015.00	0.00	0.00	221.18	122.81
5	2015.25	0.05	0.02	173.06	96.58
6	2015.50	0.20	0.08	180.68	96.85
7	2015.75	0.81	0.34	118.08	60.93
8	2016.00	0.00	0.00	180.88	79.95

Table 20: Forecast given status quo F. 'fbar5' and 'ssb5' are the 5th percentiles



[!htb]

Figure 41: **run 5** Observed versus predicted.

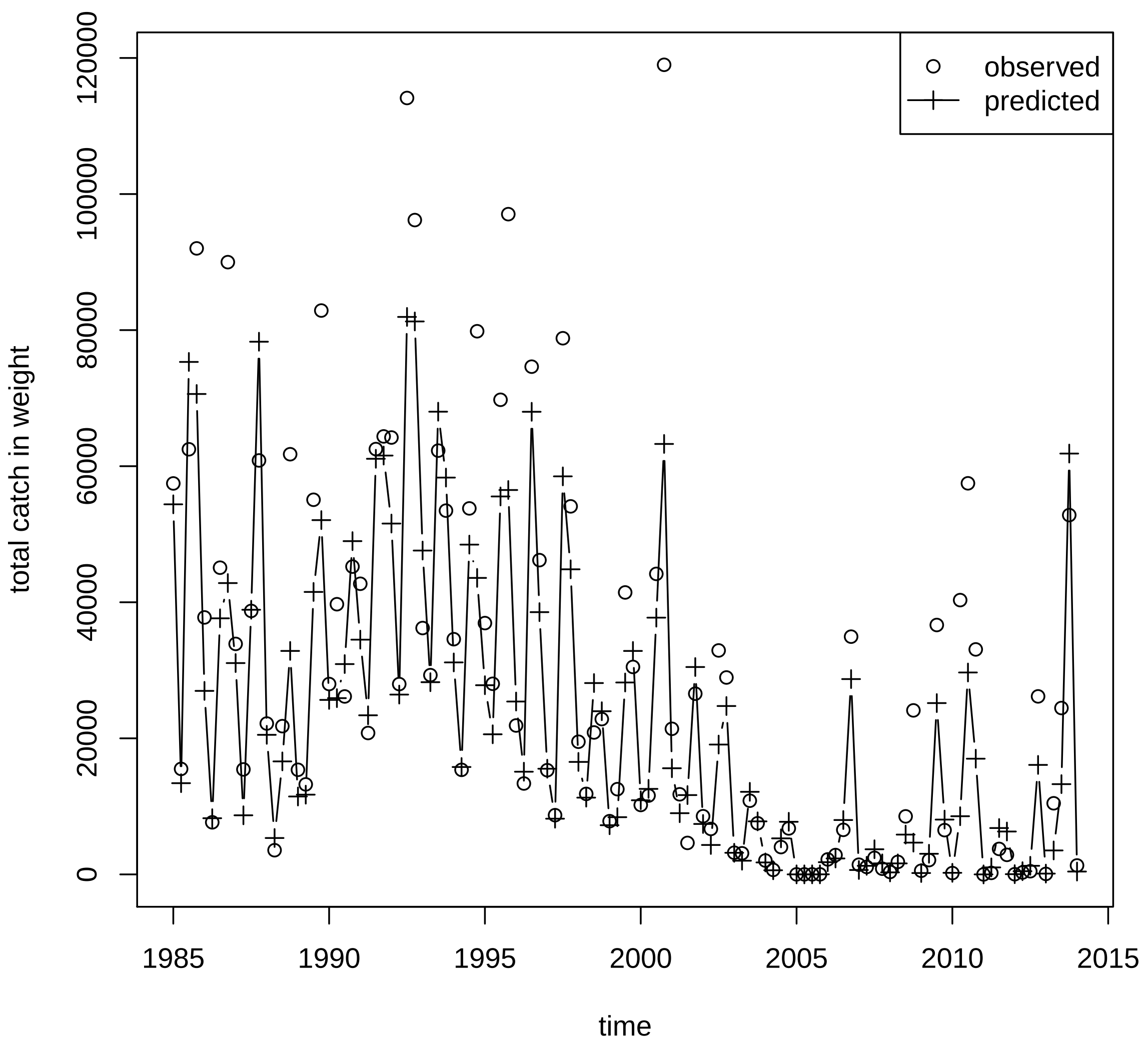


Figure 42: Total catch weight observed versus predicted by quarter.

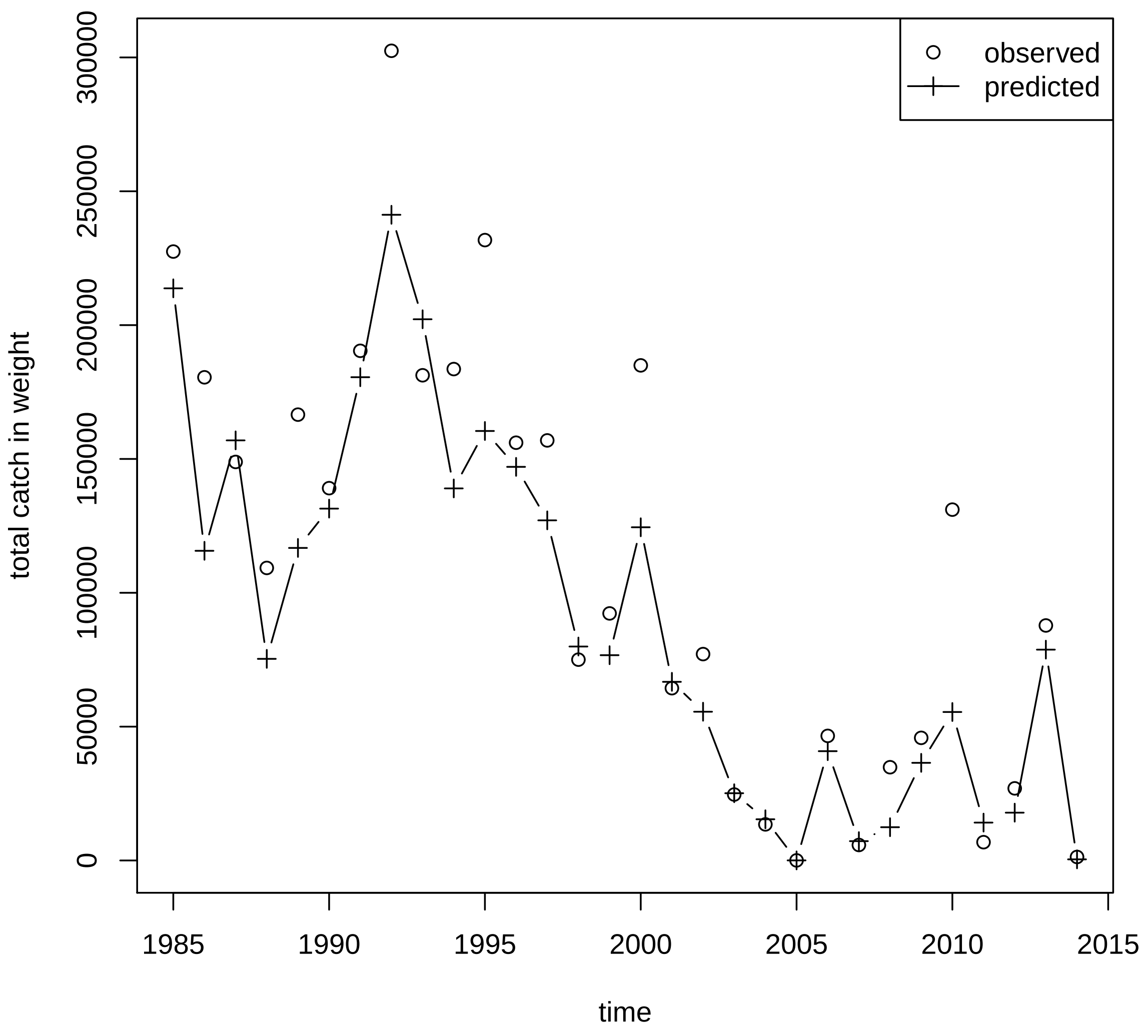


Figure 43: Total catch weight observed versus predicted by year.

	time	fbar	fbar5.0	ssb	ssb5
1	2014.25	0.00	0.00	251.34	154.23
2	2014.50	0.00	0.00	283.33	174.29
3	2014.75	0.00	0.00	194.64	119.59
4	2015.00	0.00	0.00	272.29	174.71
5	2015.25	0.00	0.00	212.06	134.41
6	2015.50	0.00	0.00	225.15	137.07
7	2015.75	0.00	0.00	153.40	92.31
8	2016.00	0.00	0.00	265.77	126.69

Table 21: Forecast given zero F. 'fbar5' and 'ssb5' are the 5th percentiles

Parameter estimates

```
              Estimate   Std. Error
logSdLogFsta -0.38949954 1.960667e-01
logSdLogN    -4.00000000 1.947580e+01
logSdLogObs   0.88030054 6.468808e-02
logSdLogObs  -0.34714677 9.614269e-02
logSdLogObs  -0.63896238 9.052506e-02
logSdLogObs  -0.50951304 1.156813e-01
logSdLogObs  -0.76981370 1.424953e-01
logSdLogObs  -0.42526961 1.171982e-01
logQ         -2.19257565 1.974076e-01
logQ         -1.57560688 2.308227e-01
logQ         -1.51044903 3.470558e-01
logQ         -2.38242528 2.330651e-01
logQ         -1.58357438 2.404675e-01
logQ         -2.29470925 2.394244e-01
logQ         -1.73522740 2.469501e-01
logQ         -1.65492649 2.937650e-01
logQ         -2.44393562 3.733885e-01
trans_rho     5.26282154 4.368801e-01
logSdLogR    -0.05257591 1.482907e-01
rho           0.99994632 4.689972e-05
```

3.6 Run 6

In run 6 the natural mortality has been multiplied with 0.5 relative to the base run.

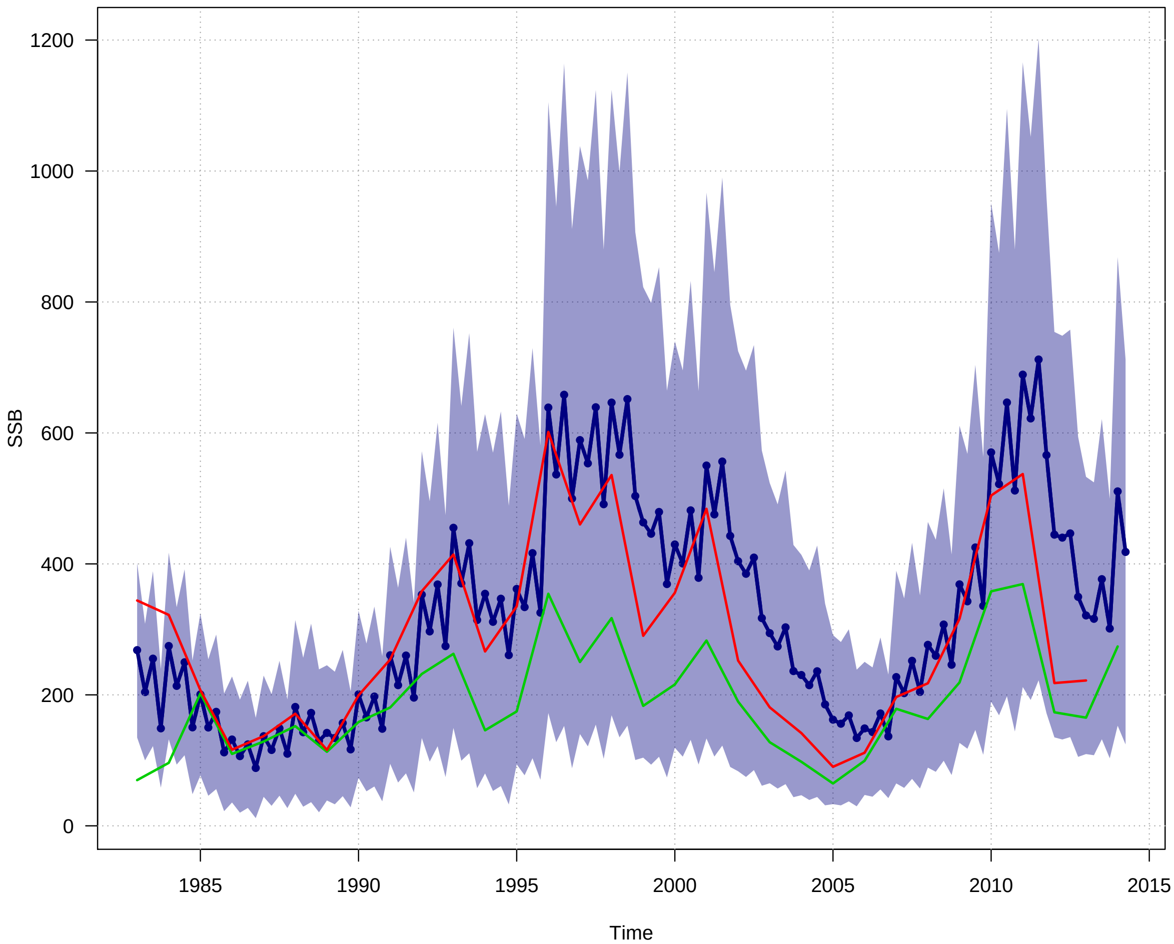


Figure 44: **run 6** SSB: Blue is SESAM, green is XSA (May 2014), red is the base run.

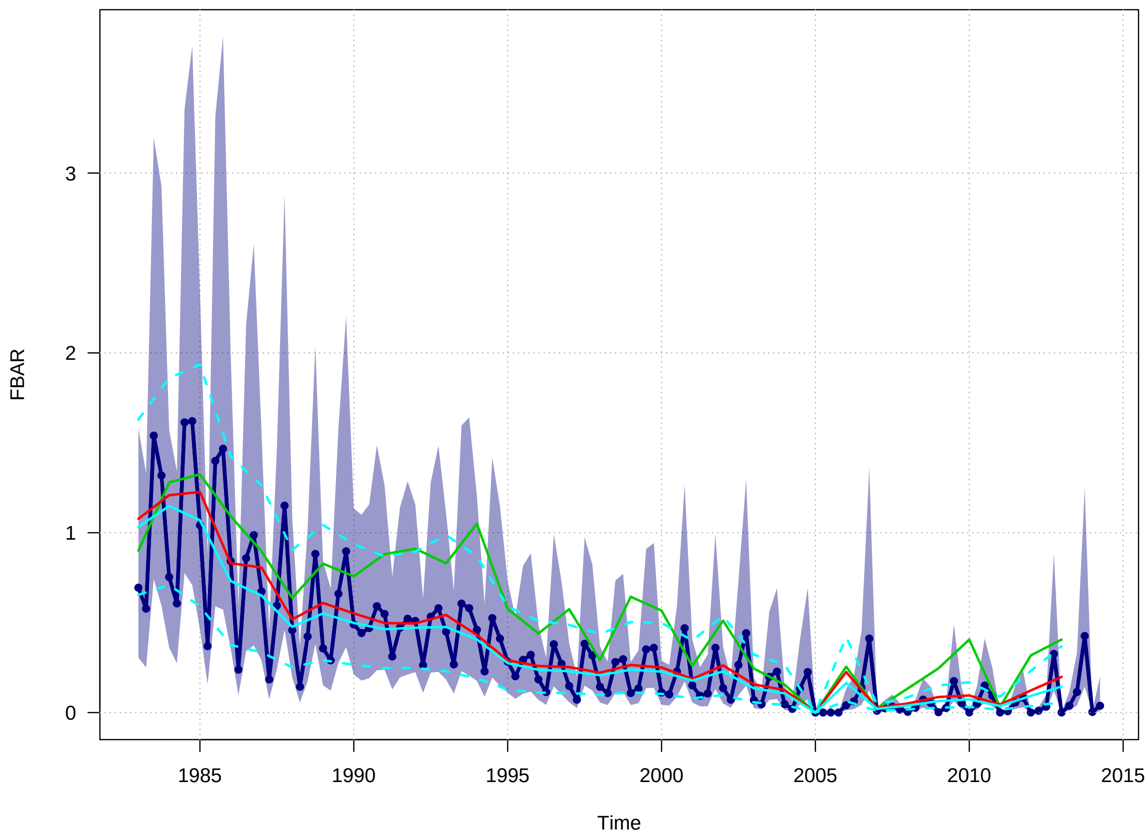


Figure 45: **run 6** $\bar{F}_{1-2}$: Blue is SESAM by quarter, cyan is SESAM yearly average, green is XSA yearly average, red is the base run.

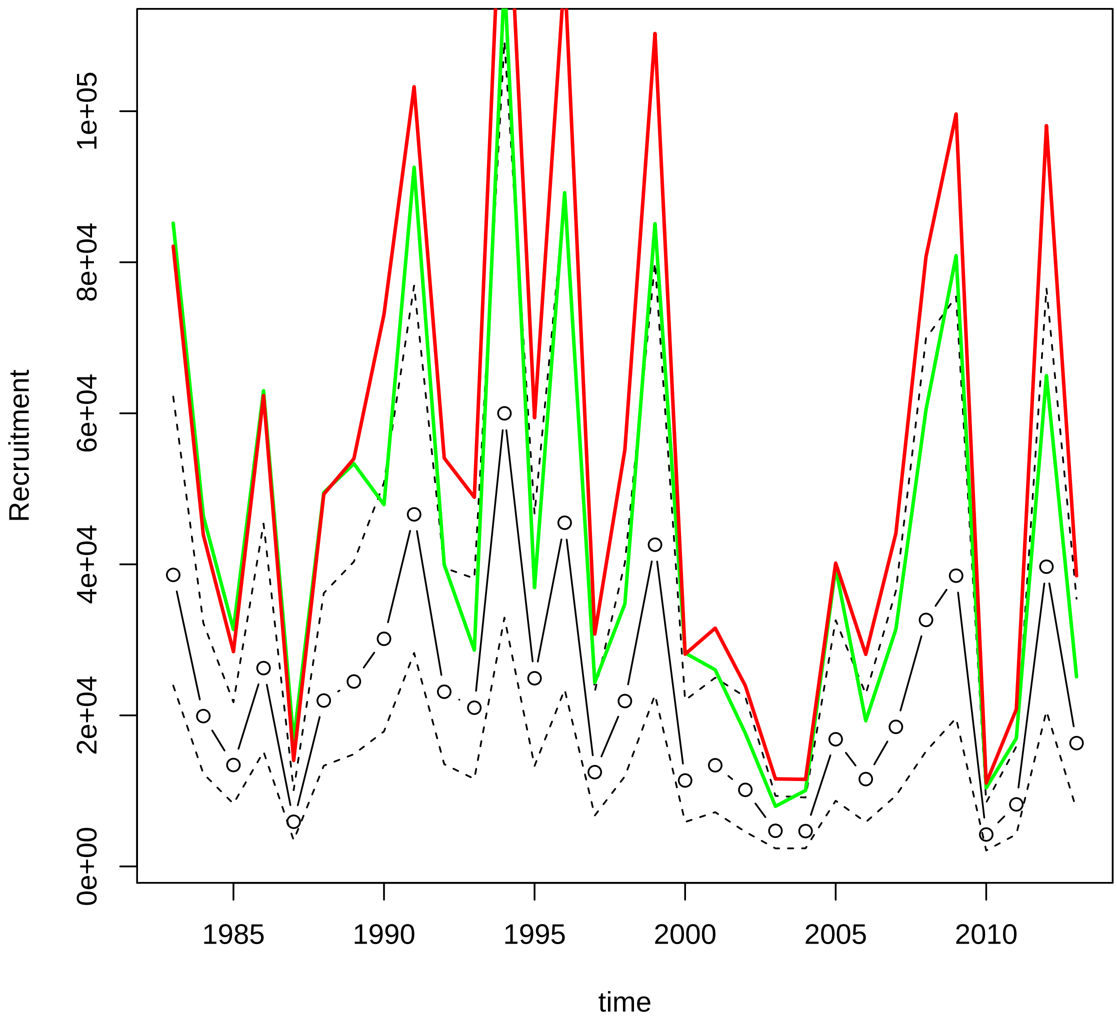


Figure 46: **run 6** Recruitment: Black is SESAM, green is XSA, red is the base run.

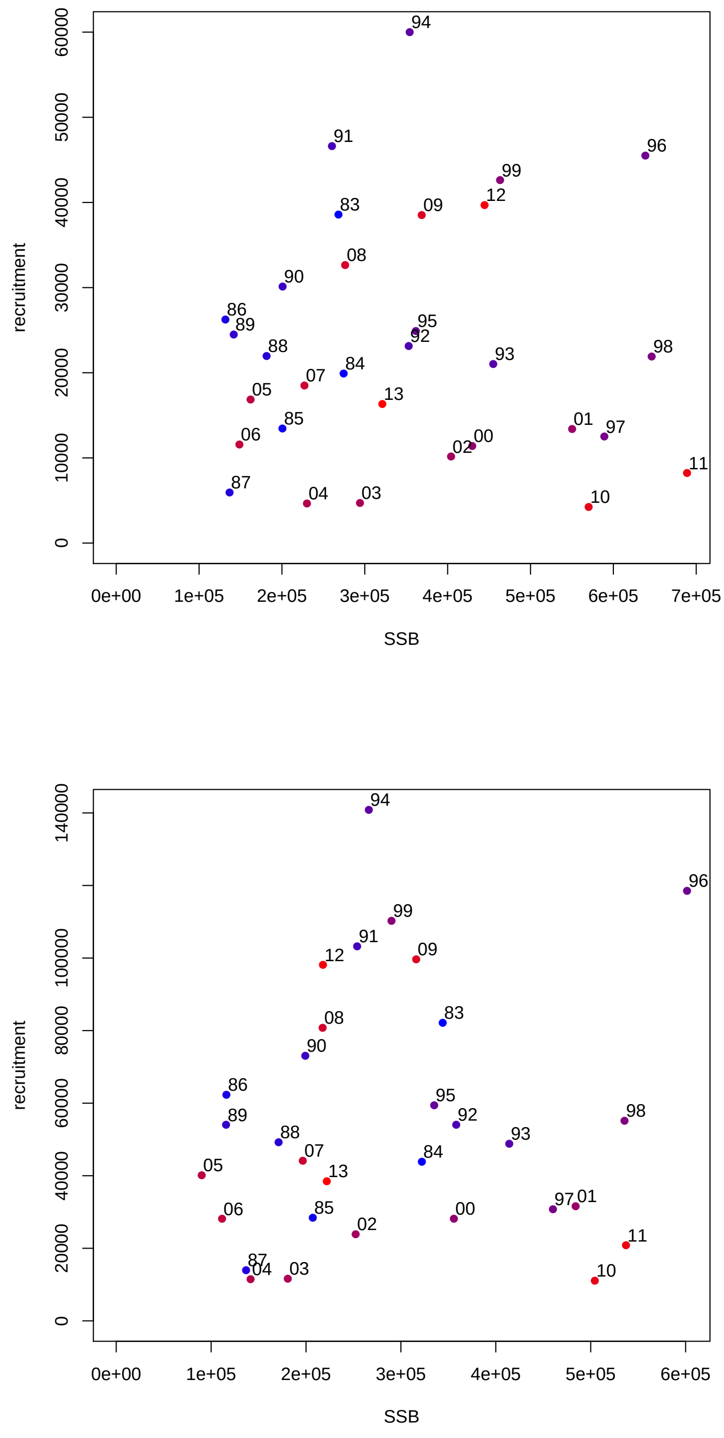


Figure 47: **run 6** Stock-Recruitment from SESAM (top). SSB is calculated in Q1, whereas recruitment is in Q3. Bottom figure is base run.

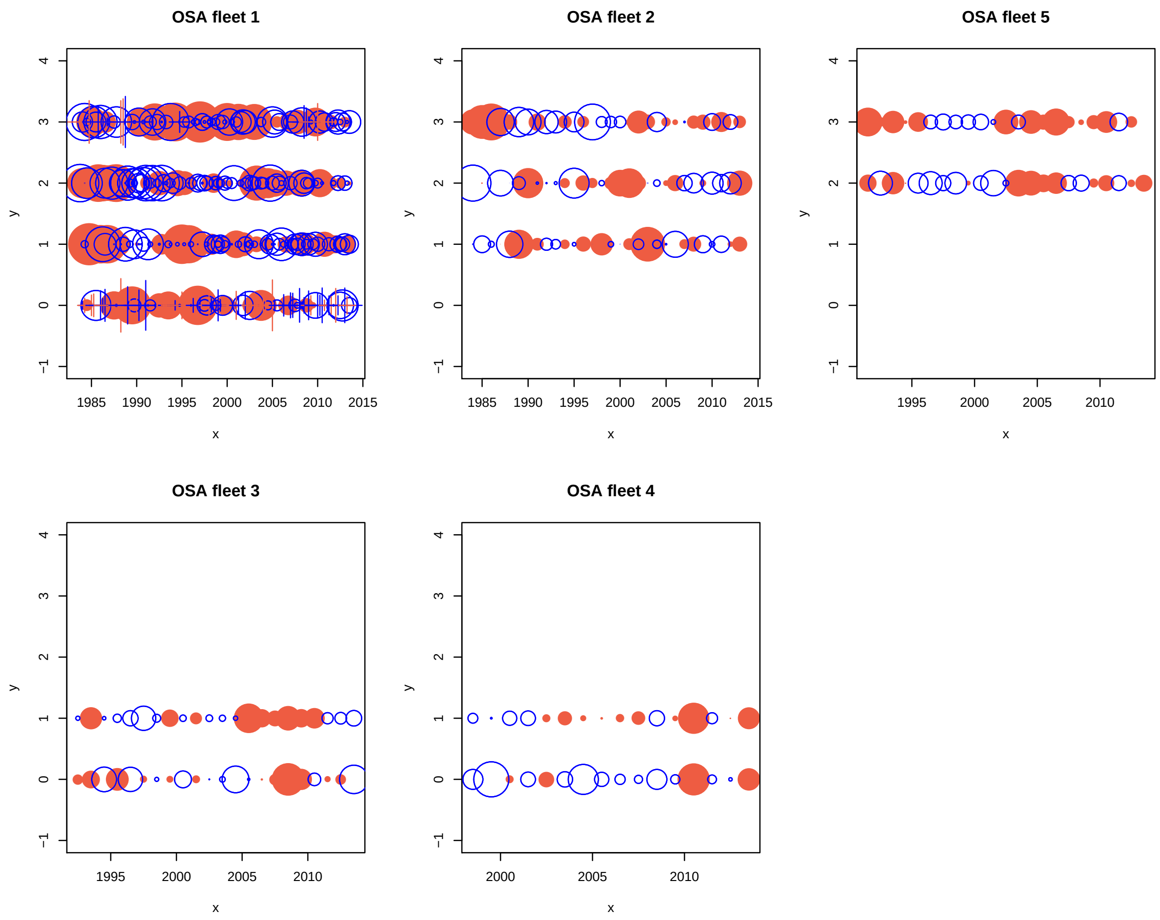


Figure 48: **run 6** SESAM one-step ahead residuals by fleet. Circles are used for positive observations while '+' denotes randomized residuals from zero observations. Blue is positive, red is negative.

	time	SSB	lo	hi
1	1983	268.32	158.56	378.08
2	1984	274.66	157.41	391.91
3	1985	200.73	98.99	302.48
4	1986	131.85	52.72	210.97
5	1987	136.88	60.73	213.04
6	1988	181.56	72.48	290.64
7	1989	141.95	57.01	226.90
8	1990	200.85	95.90	305.81
9	1991	260.50	124.14	396.87
10	1992	353.09	172.96	533.21
11	1993	455.18	203.73	706.62
12	1994	354.34	128.70	579.99
13	1995	361.76	141.46	582.06
14	1996	638.79	255.11	1022.48
15	1997	589.08	219.84	958.32
16	1998	646.37	253.66	1039.08
17	1999	463.41	167.88	758.93
18	2000	429.68	174.39	684.98
19	2001	550.23	207.39	893.08
20	2002	404.15	140.29	668.00
21	2003	294.30	105.73	482.87
22	2004	230.32	79.33	381.31
23	2005	162.15	56.05	268.26
24	2006	148.77	65.16	232.37
25	2007	227.16	93.59	360.74
26	2008	276.42	122.12	430.72
27	2009	368.79	169.64	567.95
28	2010	570.29	257.12	883.45
29	2011	689.04	296.70	1081.39
30	2012	444.68	190.07	699.28
31	2013	321.28	147.18	495.38
32	2014	510.75	216.44	805.06

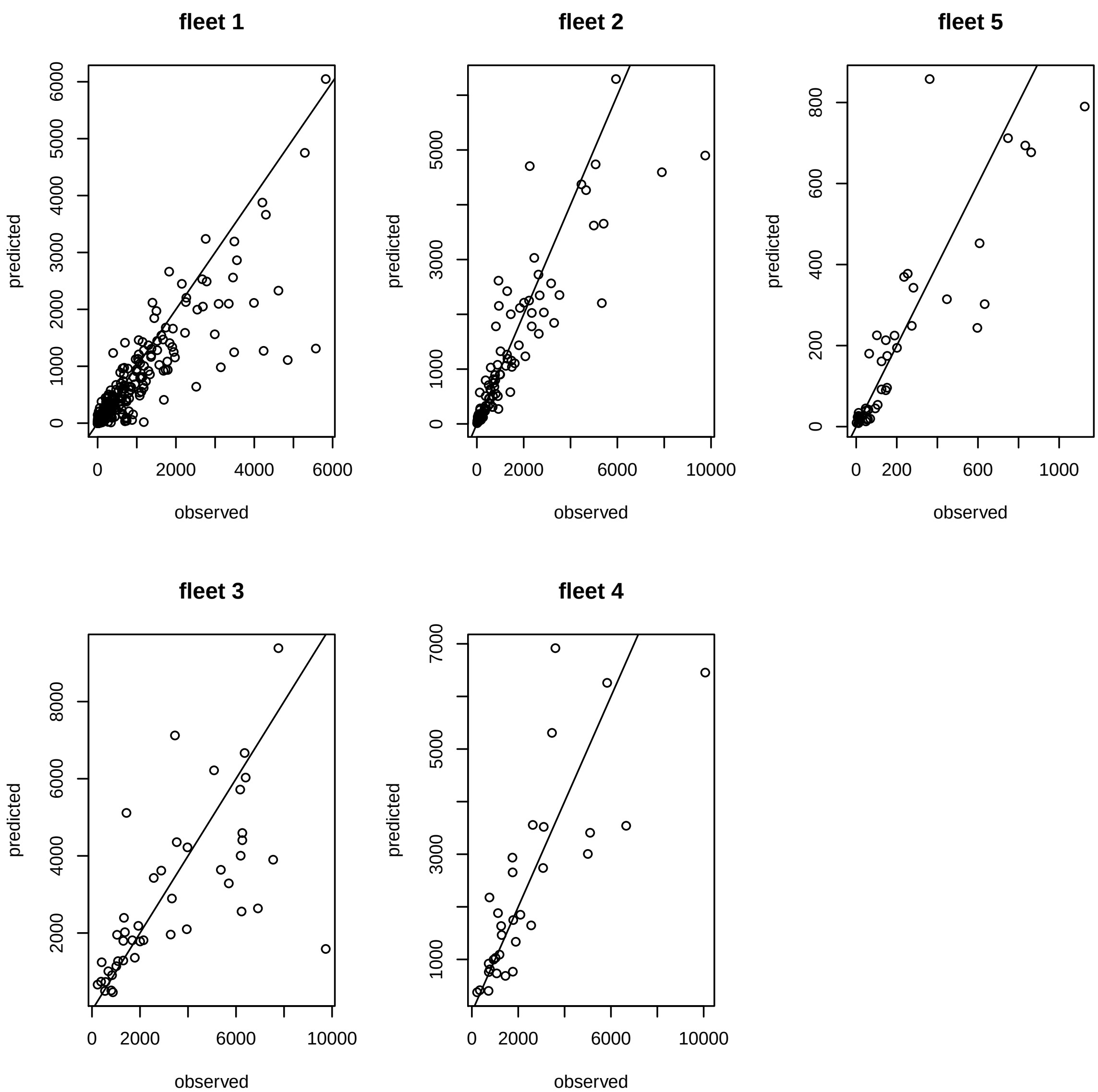
Table 22: SSB in Q1. 'lo' and 'hi' is the 5 and 95 percentiles respectively

	time	SSB	recruitment
1	1983.00	268.32	38605.11
2	1984.00	274.66	19906.33
3	1985.00	200.73	13431.26
4	1986.00	131.85	26264.40
5	1987.00	136.88	5917.07
6	1988.00	181.56	21968.10
7	1989.00	141.95	24487.70
8	1990.00	200.85	30140.94
9	1991.00	260.50	46620.49
10	1992.00	353.09	23132.17
11	1993.00	455.18	21019.60
12	1994.00	354.34	59998.71
13	1995.00	361.76	24918.45
14	1996.00	638.79	45509.30
15	1997.00	589.08	12487.97
16	1998.00	646.37	21900.00
17	1999.00	463.41	42600.08
18	2000.00	429.68	11382.99
19	2001.00	550.23	13399.90
20	2002.00	404.15	10141.66
21	2003.00	294.30	4721.59
22	2004.00	230.32	4679.45
23	2005.00	162.15	16840.82
24	2006.00	148.77	11568.05
25	2007.00	227.16	18482.40
26	2008.00	276.42	32643.71
27	2009.00	368.79	38494.45
28	2010.00	570.29	4228.26
29	2011.00	689.04	8215.14
30	2012.00	444.68	39689.42
31	2013.00	321.28	16330.02

Table 23: Estimated SSB in Q1 and recruitment in Q3

	time	fbar	fbar5	ssb	ssb5
1	2014.25	0.04	0.02	452.65	253.03
2	2014.50	0.12	0.05	557.08	309.11
3	2014.75	0.43	0.18	441.78	239.71
4	2015.00	0.00	0.00	470.43	258.33
5	2015.25	0.04	0.02	449.75	247.85
6	2015.50	0.12	0.05	499.30	275.37
7	2015.75	0.43	0.18	392.33	215.05
8	2016.00	0.00	0.00	414.77	217.24

Table 24: Forecast given status quo F. 'fbar5' and 'ssb5' are the 5th percentiles



[!htb]

Figure 49: **run 6** Observed versus predicted.

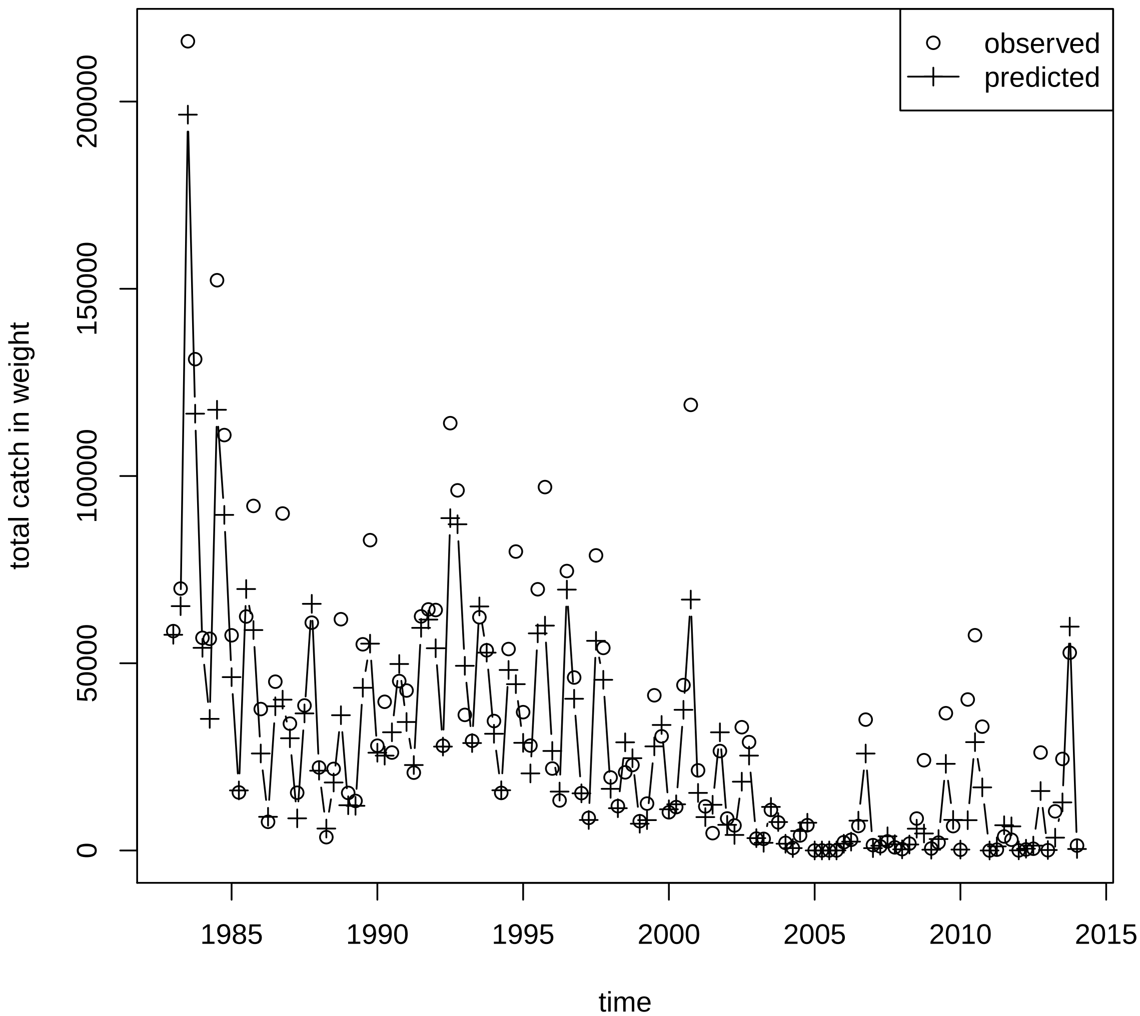


Figure 50: Total catch weight observed versus predicted by quarter.

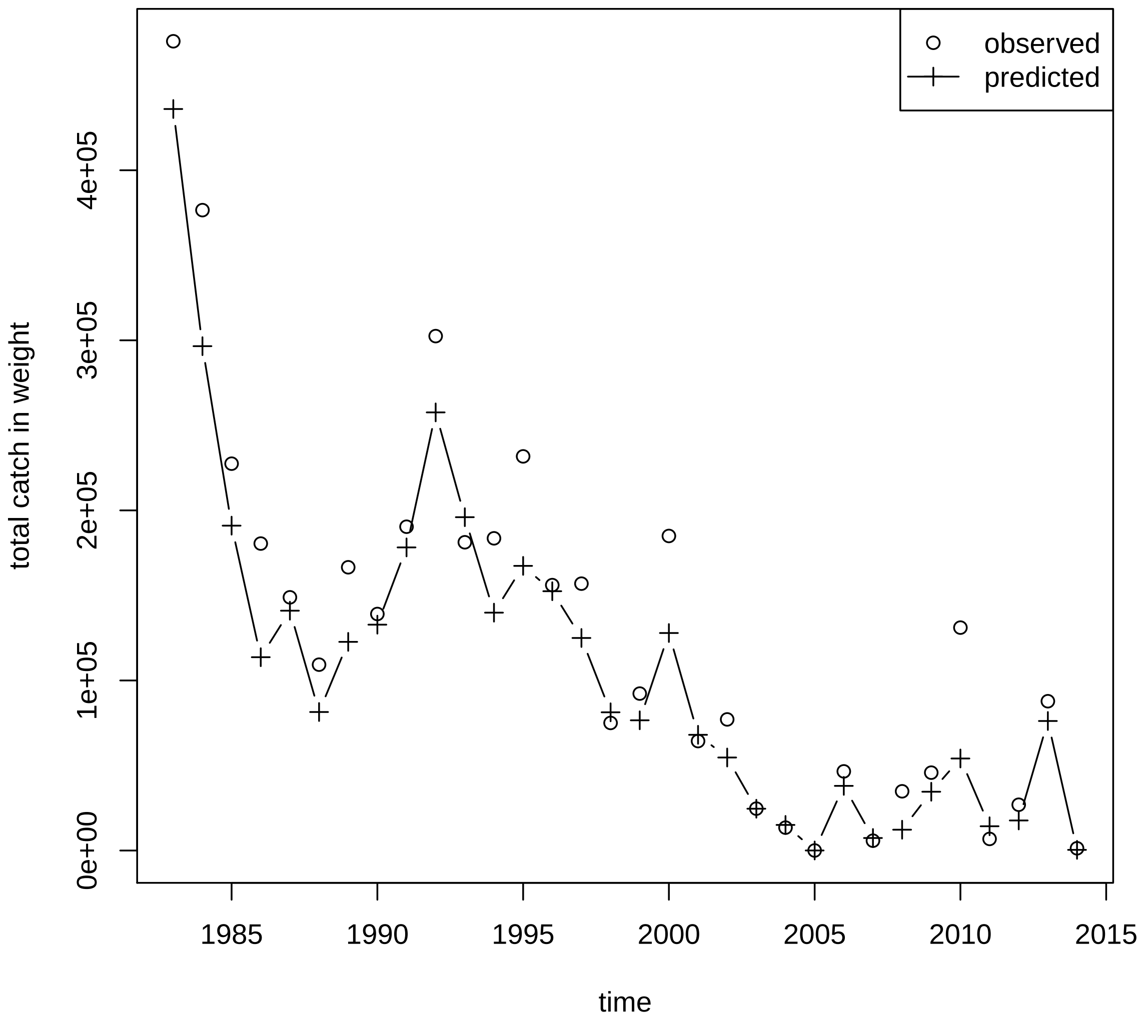


Figure 51: Total catch weight observed versus predicted by year.

	time	fbar	fbar5.0	ssb	ssb5
1	2014.25	0.00	0.00	452.96	253.28
2	2014.50	0.00	0.00	563.66	314.67
3	2014.75	0.00	0.00	459.48	256.61
4	2015.00	0.00	0.00	510.90	297.18
5	2015.25	0.00	0.00	486.77	284.25
6	2015.50	0.00	0.00	548.38	321.42
7	2015.75	0.00	0.00	439.33	258.25
8	2016.00	0.00	0.00	499.11	278.33

Table 25: Forecast given zero F. 'fbar5' and 'ssb5' are the 5th percentiles

Parameter estimates

```
                Estimate   Std. Error
logSdLogFsta -0.46587262 2.125070e-01
logSdLogN    -2.66568964 3.810024e+00
logSdLogObs   0.90314410 6.256002e-02
logSdLogObs  -0.35712756 9.727371e-02
logSdLogObs  -0.56775246 8.595565e-02
logSdLogObs  -0.52193522 1.239748e-01
logSdLogObs  -0.75578032 1.520942e-01
logSdLogObs  -0.37881597 1.127986e-01
logQ         -1.84231298 2.470393e-01
logQ         -1.80598468 3.095974e-01
logQ         -3.17418109 4.084801e-01
logQ         -1.76662697 2.897969e-01
logQ         -1.52394877 3.060091e-01
logQ         -1.70774540 3.003562e-01
logQ         -1.71221619 3.137894e-01
logQ         -2.39037398 3.736764e-01
logQ         -4.59800864 4.176932e-01
trans_rho     5.35778963 5.371490e-01
logSdLogR    -0.08011774 1.540767e-01
rho           0.99995561 4.768904e-05
```

3.7 run 7

Without 1983.

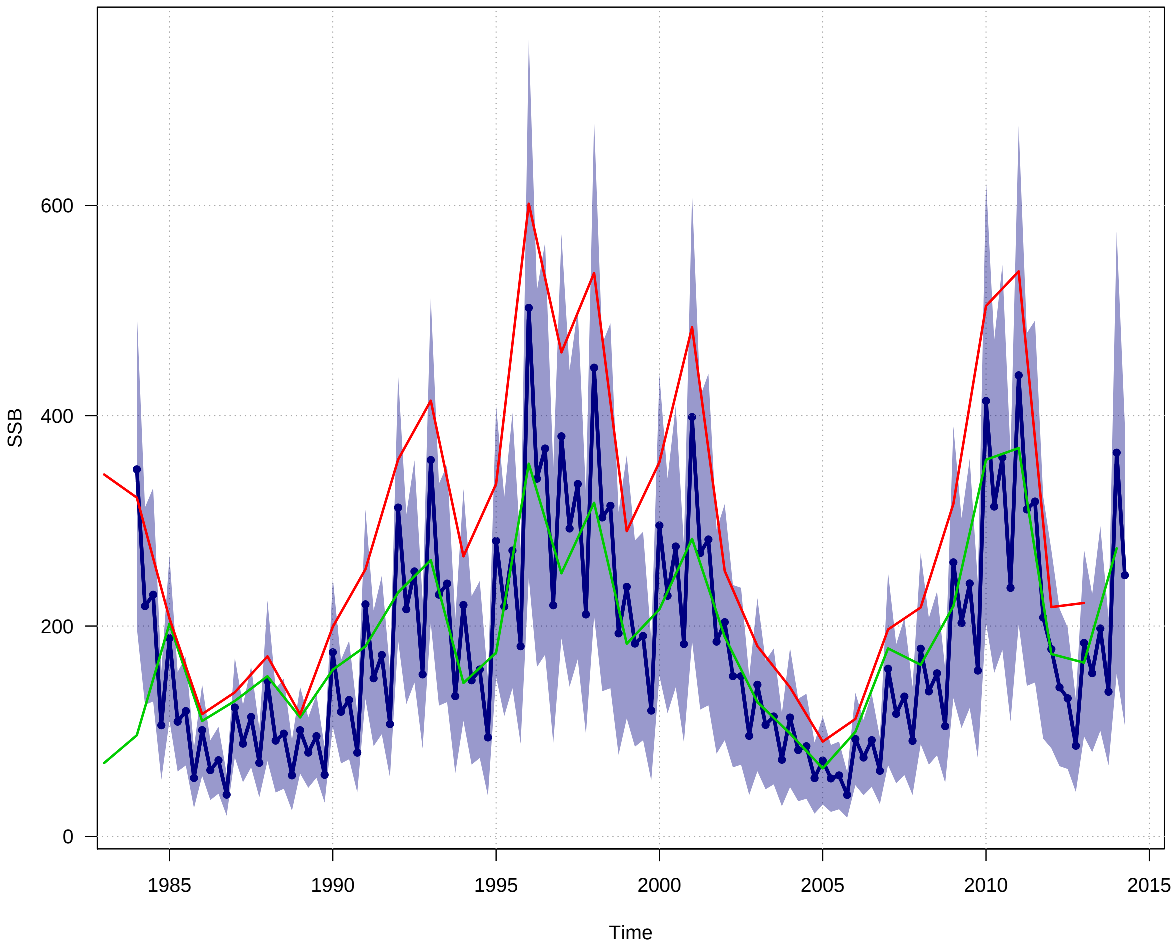


Figure 52: **run 7** SSB: Blue is SESAM, green is XSA (May 2014), red is the base run.

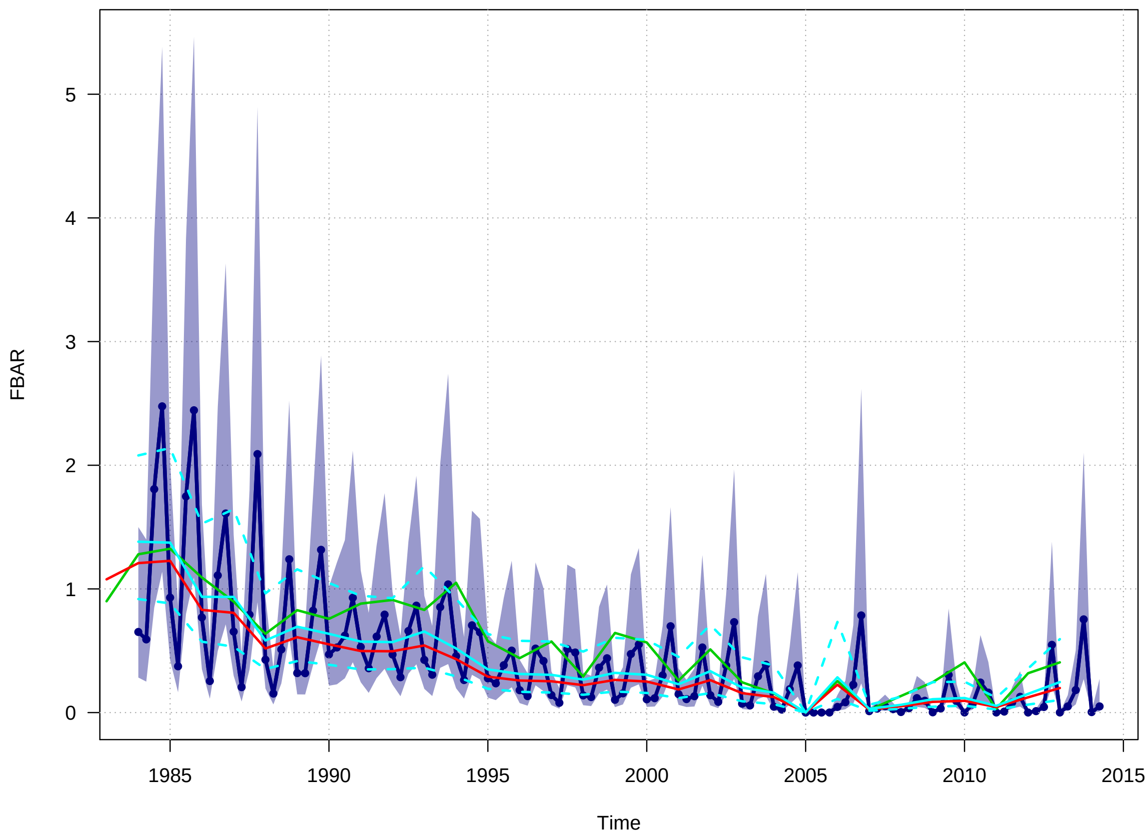


Figure 53: **run 7** $\bar{F}_{1-2}$: Blue is SESAM by quarter, cyan is SESAM yearly average, green is XSA yearly average, red is the base run.

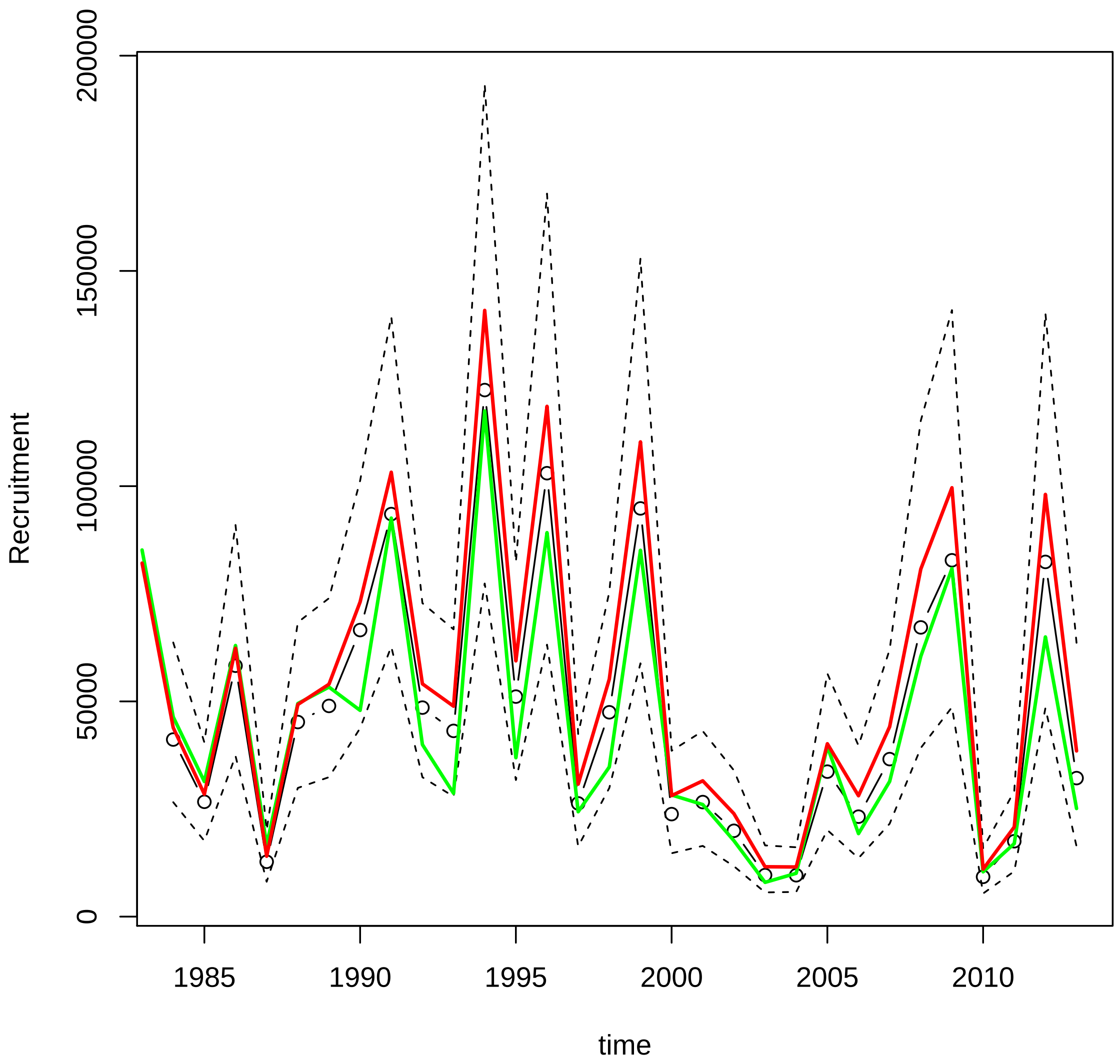
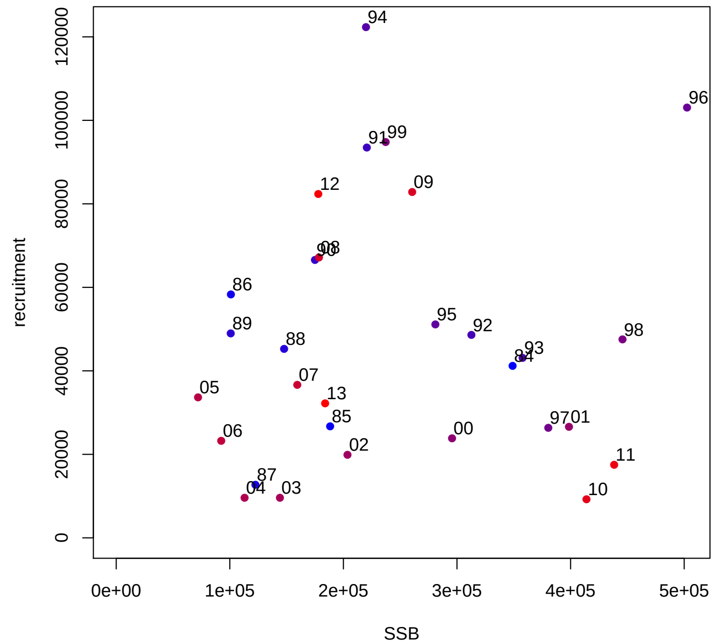


Figure 54: **run 7** Recruitment: Black is SESAM, green is XSA, red is the base run.



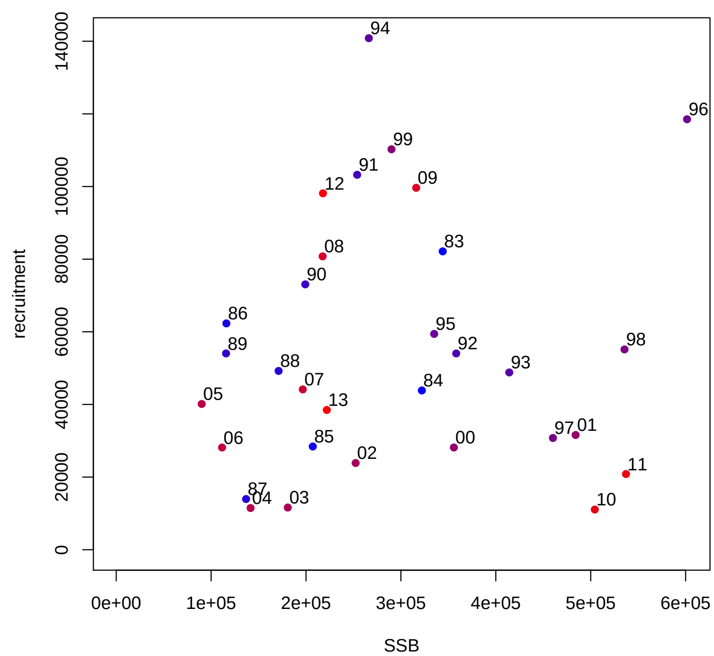


Figure 55: **run 7** Stock-Recruitment from SESAM (top). SSB is calculated in Q1, whereas recruitment is in Q3. Bottom figure is base run.

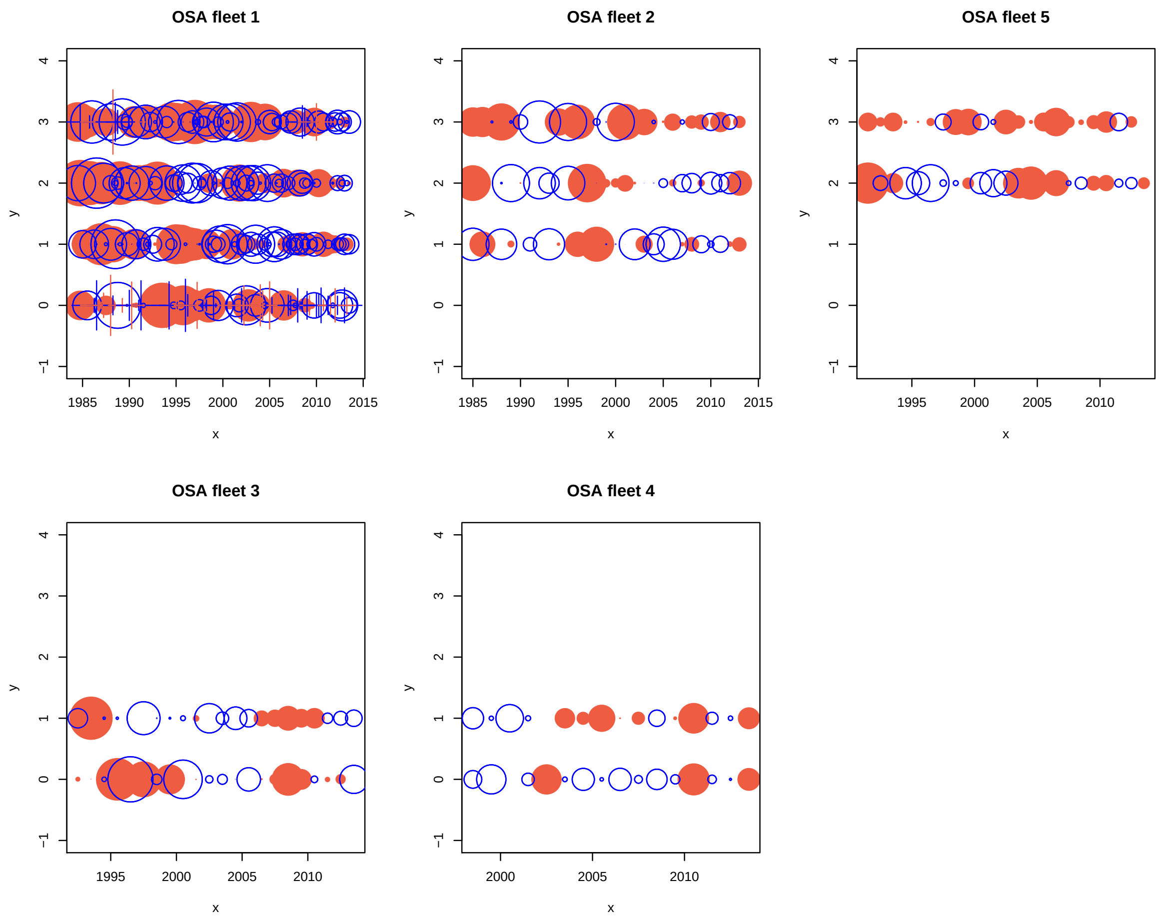


Figure 56: **run 7** SESAM one-step ahead residuals by fleet. Circles are used for positive observations while '+' denotes randomized residuals from zero observations. Blue is positive, red is negative.

	time	SSB	lo	hi
1	1984	348.99	225.12	472.86
2	1985	188.43	124.08	252.79
3	1986	101.00	65.23	136.78
4	1987	122.58	83.48	161.69
5	1988	147.92	85.18	210.65
6	1989	100.93	67.04	134.83
7	1990	175.04	117.02	233.05
8	1991	220.66	146.57	294.75
9	1992	312.69	208.81	416.56
10	1993	357.86	230.50	485.23
11	1994	220.00	129.36	310.64
12	1995	281.01	174.72	387.31
13	1996	502.61	291.84	713.38
14	1997	380.42	222.31	538.52
15	1998	445.70	251.49	639.92
16	1999	237.29	134.40	340.17
17	2000	295.68	177.94	413.42
18	2001	398.72	223.65	573.79
19	2002	203.67	111.34	296.00
20	2003	144.20	76.52	211.89
21	2004	113.01	58.57	167.44
22	2005	72.10	37.61	106.59
23	2006	92.57	56.44	128.71
24	2007	159.44	84.05	234.83
25	2008	178.48	103.70	253.26
26	2009	260.57	154.29	366.85
27	2010	414.05	240.62	587.48
28	2011	438.43	243.40	633.45
29	2012	178.03	100.50	255.57
30	2013	183.98	110.85	257.12
31	2014	364.88	191.91	537.85

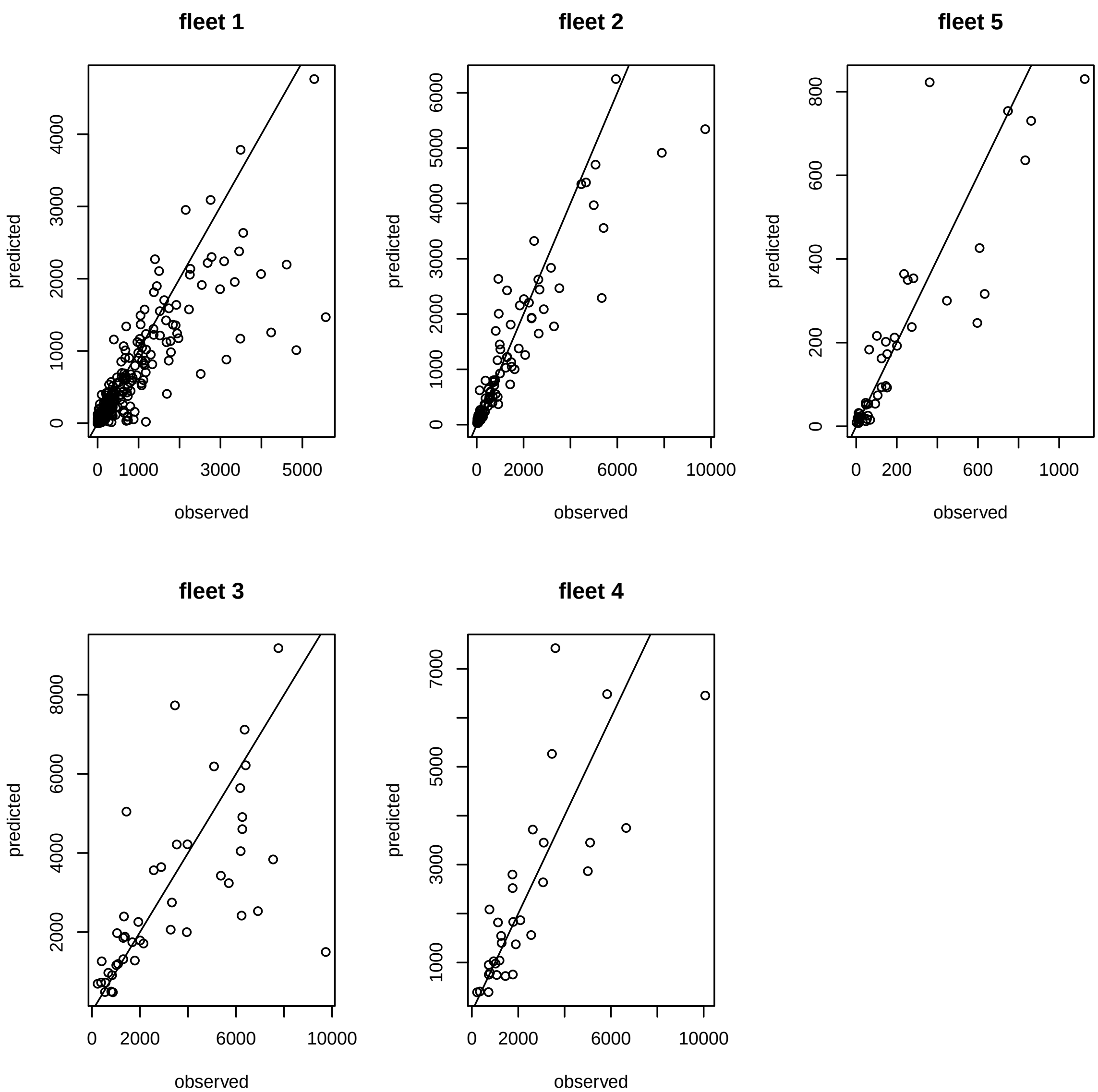
Table 26: SSB in Q1. 'lo' and 'hi' is the 5 and 95 percentiles respectively

	time	SSB	recruitment
1	1984.00	348.99	41143.87
2	1985.00	188.43	26675.17
3	1986.00	101.00	58289.74
4	1987.00	122.58	12746.72
5	1988.00	147.92	45207.31
6	1989.00	100.93	48950.73
7	1990.00	175.04	66574.99
8	1991.00	220.66	93517.86
9	1992.00	312.69	48558.49
10	1993.00	357.86	43150.84
11	1994.00	220.00	122324.84
12	1995.00	281.01	51114.44
13	1996.00	502.61	103013.88
14	1997.00	380.42	26311.36
15	1998.00	445.70	47477.40
16	1999.00	237.29	94835.93
17	2000.00	295.68	23818.06
18	2001.00	398.72	26614.42
19	2002.00	203.67	19946.38
20	2003.00	144.20	9648.61
21	2004.00	113.01	9615.67
22	2005.00	72.10	33689.87
23	2006.00	92.57	23229.04
24	2007.00	159.44	36597.79
25	2008.00	178.48	67193.79
26	2009.00	260.57	82785.04
27	2010.00	414.05	9245.32
28	2011.00	438.43	17516.59
29	2012.00	178.03	82407.64
30	2013.00	183.98	32187.21

Table 27: Estimated SSB in Q1 and recruitment in Q3

	time	fbar	fbar5	ssb	ssb5
1	2014.25	0.05	0.02	262.16	162.70
2	2014.50	0.18	0.08	289.27	179.02
3	2014.75	0.77	0.33	186.07	111.63
4	2015.00	0.00	0.00	230.80	133.14
5	2015.25	0.05	0.02	181.33	104.77
6	2015.50	0.18	0.08	187.21	104.94
7	2015.75	0.77	0.33	122.64	66.85
8	2016.00	0.00	0.00	188.28	86.74

Table 28: Forecast given status quo F. 'fbar5' and 'ssb5' are the 5th percentiles



[!htb]

Figure 57: **run 7** Observed versus predicted.

	time	fbar	fbar5.0	ssb	ssb5
1	2014.25	0.00	0.00	262.50	163.22
2	2014.50	0.00	0.00	294.75	183.86
3	2014.75	0.00	0.00	202.80	126.81
4	2015.00	0.00	0.00	281.96	181.75
5	2015.25	0.00	0.00	219.54	140.35
6	2015.50	0.00	0.00	232.24	143.45
7	2015.75	0.00	0.00	157.82	96.68
8	2016.00	0.00	0.00	270.80	134.39

Table 29: Forecast given zero F. 'fbar5' and 'ssb5' are the 5th percentiles

Parameter estimates

```
                Estimate   Std. Error
logSdLogFsta -0.39782473 1.893602e-01
logSdLogN    -4.00000000 1.765474e+01
logSdLogObs   0.91023112 6.380487e-02
logSdLogObs  -0.36272725 9.398721e-02
logSdLogObs  -0.64757696 8.894566e-02
logSdLogObs  -0.50732275 1.153137e-01
logSdLogObs  -0.77109653 1.420923e-01
logSdLogObs  -0.42460106 1.168632e-01
logQ         -2.21461403 1.874743e-01
logQ         -1.62806292 2.188063e-01
logQ         -1.56519572 3.301265e-01
logQ         -2.41511573 2.269417e-01
logQ         -1.61874961 2.337151e-01
logQ         -2.32935646 2.320872e-01
logQ         -1.77249792 2.389745e-01
logQ         -1.70043776 2.826649e-01
logQ         -2.49724374 3.564953e-01
trans_rho     5.35059020 4.907860e-01
logSdLogR    -0.06780765 1.459797e-01
rho           0.99995496 4.420475e-05
```

3.8 run 8

Without 1983, 1984, and 1985.

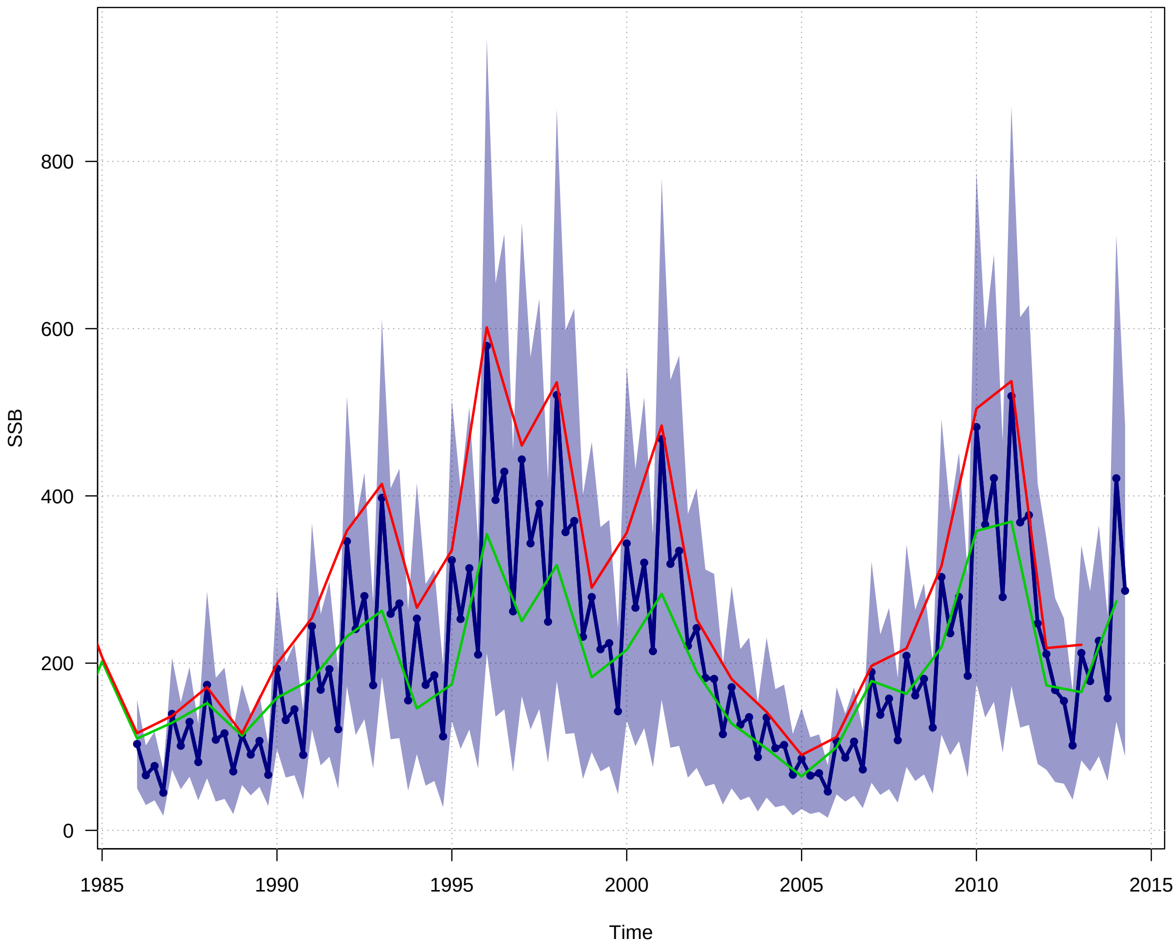


Figure 58: **run 8** SSB: Blue is SESAM, green is XSA (May 2014), red is the base run.

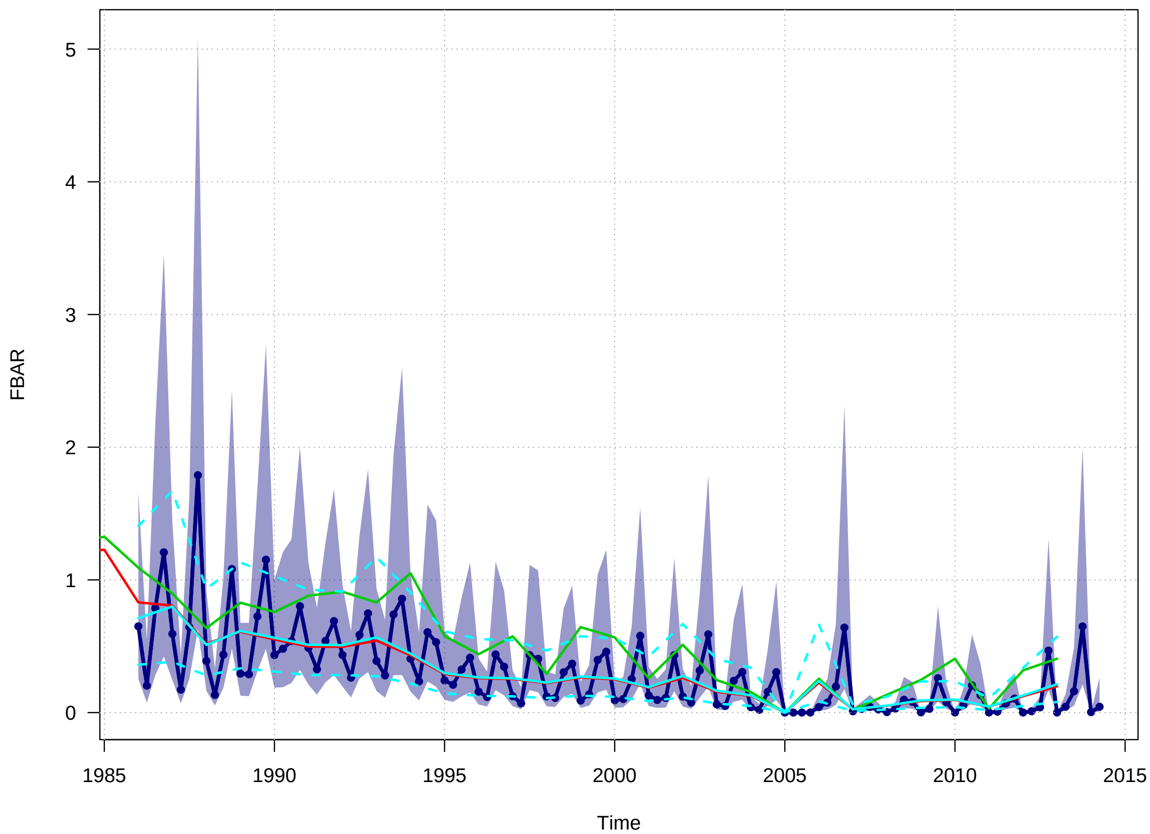


Figure 59: **run 8** $\bar{F}_{1-2}$: Blue is SESAM by quarter, cyan is SESAM yearly average, green is XSA yearly average, red is the base run.

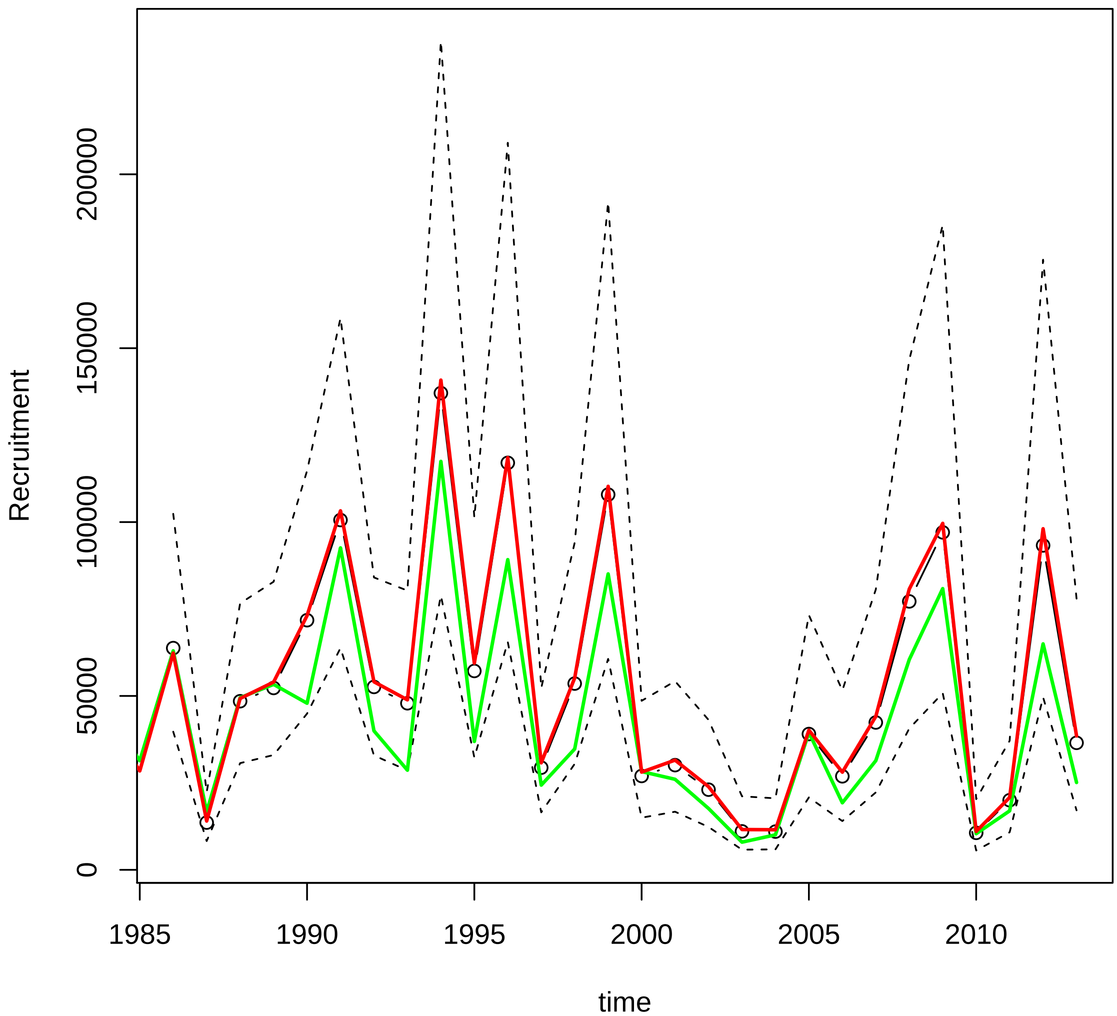


Figure 60: **run 8** Recruitment: Black is SESAM, green is XSA, red is the base run.

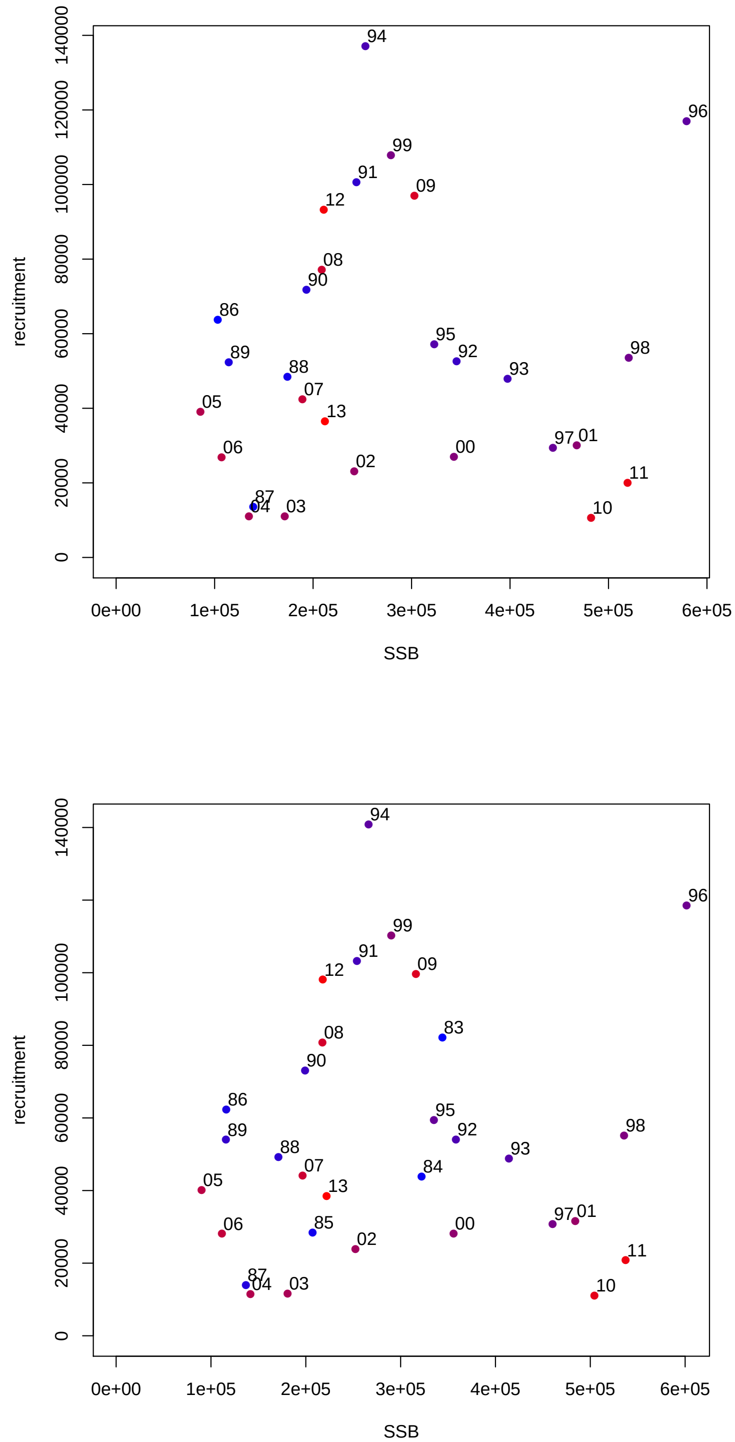


Figure 61: **run 8** Stock-Recruitment from SESAM (top). SSB is calculated in Q1, whereas recruitment is in Q3. Bottom figure is base run.

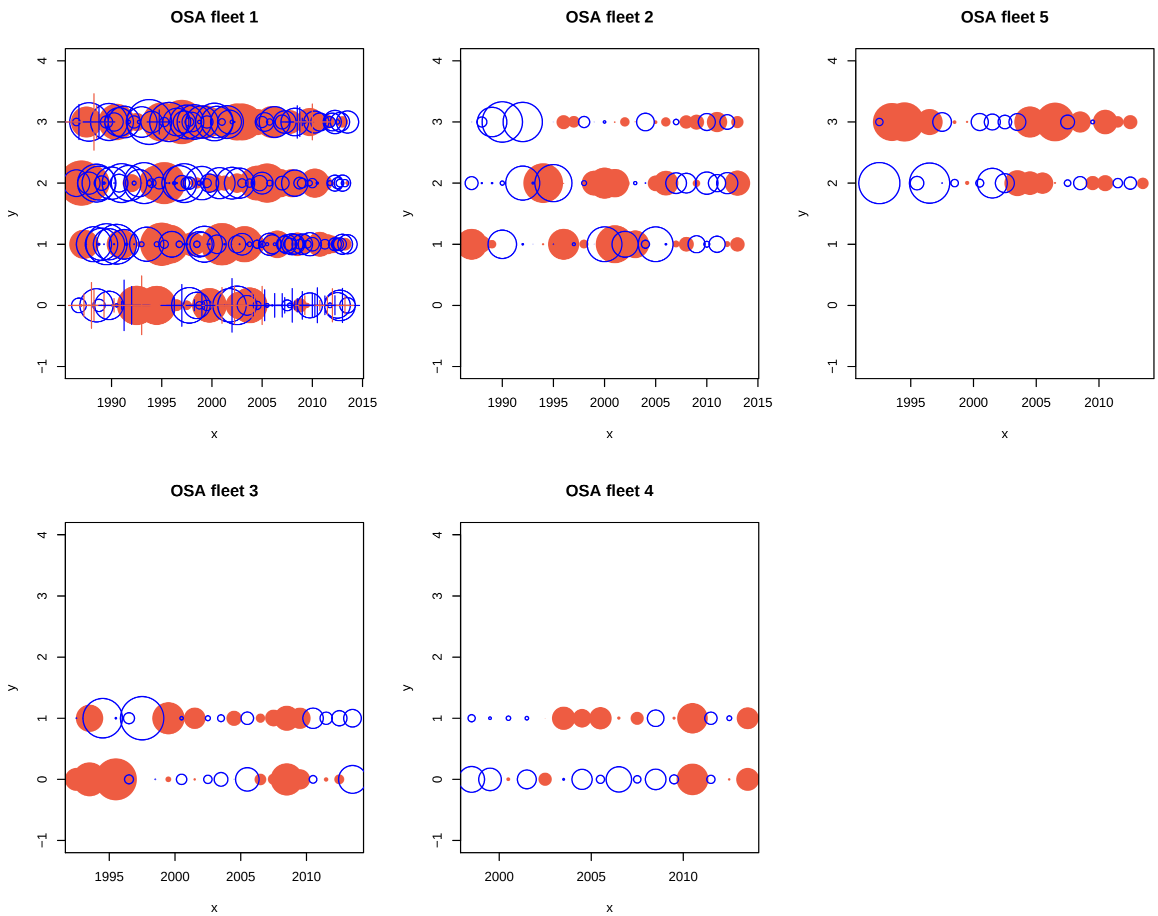


Figure 62: **run 8** SESAM one-step ahead residuals by fleet. Circles are used for positive observations while '+' denotes randomized residuals from zero observations. Blue is positive, red is negative.

	time	SSB	lo	hi
1	1986	103.31	59.75	146.88
2	1987	139.35	84.35	194.35
3	1988	174.00	82.22	265.78
4	1989	114.44	64.90	163.97
5	1990	193.31	114.26	272.36
6	1991	244.06	142.67	345.45
7	1992	345.72	202.96	488.47
8	1993	397.63	221.74	573.52
9	1994	253.28	119.97	386.58
10	1995	323.10	164.94	481.27
11	1996	579.38	277.20	881.56
12	1997	443.58	210.83	676.33
13	1998	520.64	239.15	802.14
14	1999	279.07	126.48	431.66
15	2000	343.17	168.96	517.37
16	2001	467.89	211.50	724.27
17	2002	241.93	104.33	379.52
18	2003	171.22	71.66	270.79
19	2004	134.87	56.07	213.67
20	2005	85.67	36.14	135.20
21	2006	107.15	54.39	159.90
22	2007	189.28	80.41	298.16
23	2008	208.83	99.42	318.24
24	2009	303.02	147.91	458.13
25	2010	482.36	230.25	734.47
26	2011	519.38	234.34	804.41
27	2012	210.83	97.08	324.57
28	2013	212.16	106.47	317.86
29	2014	421.10	181.60	660.59

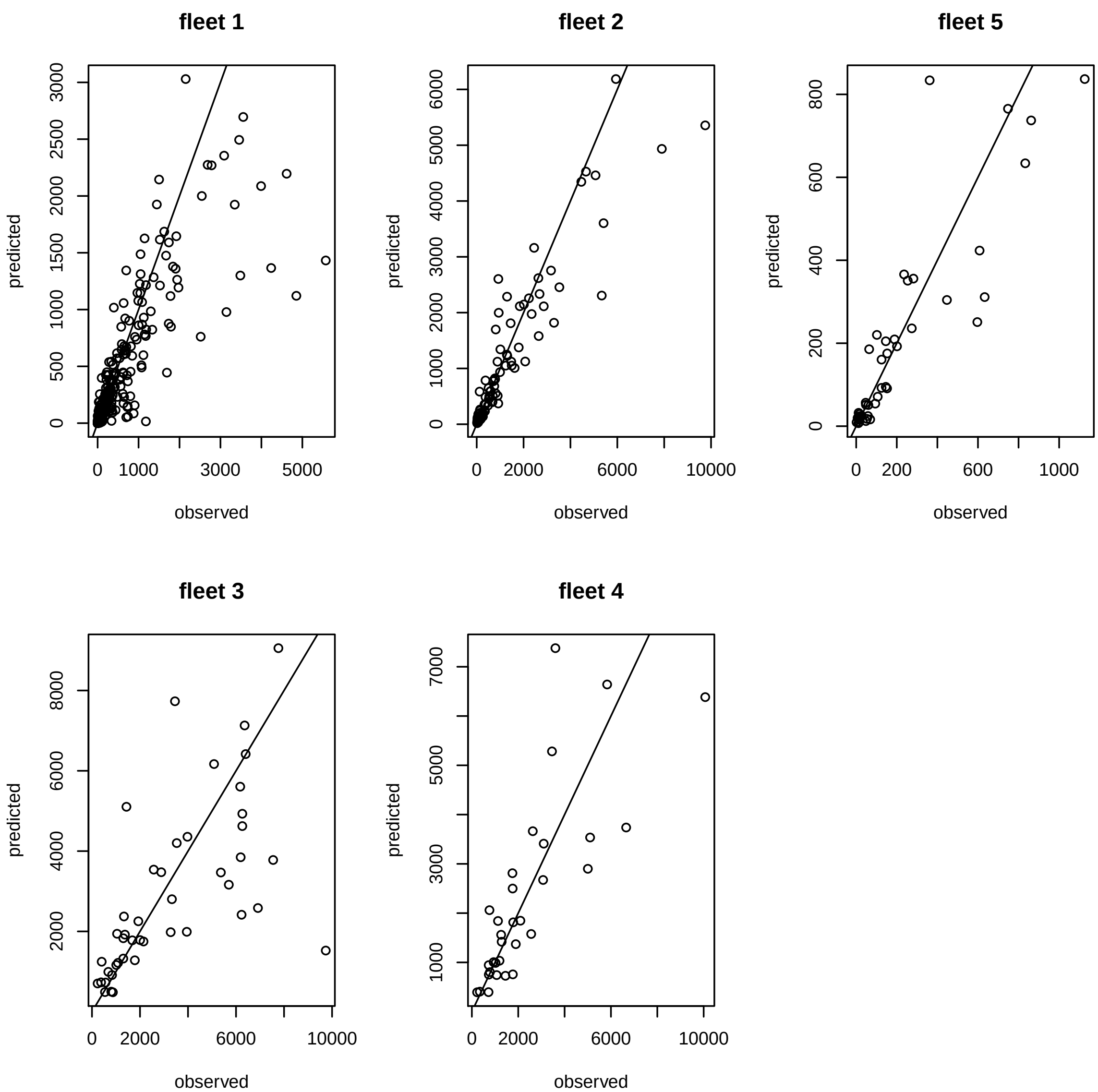
Table 30: SSB in Q1. 'lo' and 'hi' is the 5 and 95 percentiles respectively

	time	SSB	recruitment
1	1986.00	103.31	63771.28
2	1987.00	139.35	13594.59
3	1988.00	174.00	48489.33
4	1989.00	114.44	52301.77
5	1990.00	193.31	71789.38
6	1991.00	244.06	100597.10
7	1992.00	345.72	52599.78
8	1993.00	397.63	47906.02
9	1994.00	253.28	137097.51
10	1995.00	323.10	57191.68
11	1996.00	579.38	117032.77
12	1997.00	443.58	29386.84
13	1998.00	520.64	53565.30
14	1999.00	279.07	107909.93
15	2000.00	343.17	26997.89
16	2001.00	467.89	30111.89
17	2002.00	241.93	23056.74
18	2003.00	171.22	11070.77
19	2004.00	134.87	11001.79
20	2005.00	85.67	39062.80
21	2006.00	107.15	26902.02
22	2007.00	189.28	42378.34
23	2008.00	208.83	77196.11
24	2009.00	303.02	97045.53
25	2010.00	482.36	10641.04
26	2011.00	519.38	20027.86
27	2012.00	210.83	93291.59
28	2013.00	212.16	36522.57

Table 31: Estimated SSB in Q1 and recruitment in Q3

	time	fbar	fbar5	ssb	ssb5
1	2014.25	0.04	0.02	301.12	170.63
2	2014.50	0.16	0.06	332.32	187.11
3	2014.75	0.66	0.26	215.82	116.62
4	2015.00	0.00	0.00	270.08	145.72
5	2015.25	0.04	0.02	212.05	114.75
6	2015.50	0.16	0.06	221.62	116.62
7	2015.75	0.66	0.26	145.64	74.09
8	2016.00	0.00	0.00	225.34	99.75

Table 32: Forecast given status quo F. 'fbar5' and 'ssb5' are the 5th percentiles



[!htb]

Figure 63: **run 8** Observed versus predicted.

	time	fbar	fbar5.0	ssb	ssb5
1	2014.25	0.00	0.00	301.54	170.89
2	2014.50	0.00	0.00	338.29	192.62
3	2014.75	0.00	0.00	232.50	132.25
4	2015.00	0.00	0.00	321.78	195.60
5	2015.25	0.00	0.00	251.77	151.78
6	2015.50	0.00	0.00	266.73	156.94
7	2015.75	0.00	0.00	182.18	105.78
8	2016.00	0.00	0.00	309.26	148.02

Table 33: Forecast given zero F. 'fbar5' and 'ssb5' are the 5th percentiles

Parameter estimates

```
               Estimate   Std. Error
logSdLogFsta -0.3735957 2.057461e-01
logSdLogN    -4.0000000 1.052187e+01
logSdLogObs   0.8640896 6.560511e-02
logSdLogObs  -0.3378024 1.015640e-01
logSdLogObs  -0.6515812 9.121463e-02
logSdLogObs  -0.5073017 1.145527e-01
logSdLogObs  -0.7750838 1.416808e-01
logSdLogObs  -0.4220508 1.161581e-01
logQ         -2.3402637 2.467687e-01
logQ         -1.7737635 2.888264e-01
logQ         -1.7743100 4.065936e-01
logQ         -2.5422904 2.805104e-01
logQ         -1.7489679 2.898946e-01
logQ         -2.4643668 2.893105e-01
logQ         -1.9110519 2.982583e-01
logQ         -1.8650993 3.498653e-01
logQ         -2.7213021 4.284419e-01
trans_rho     5.2143044 4.101827e-01
logSdLogR    -0.0443999 1.495780e-01
rho           0.9999409 4.852041e-05
```

3.9 run 9

log F random walk variance NOT inflated for increments that involve years where the fishery was closed (end point in the period Q1 2005 to 2007 Q4).

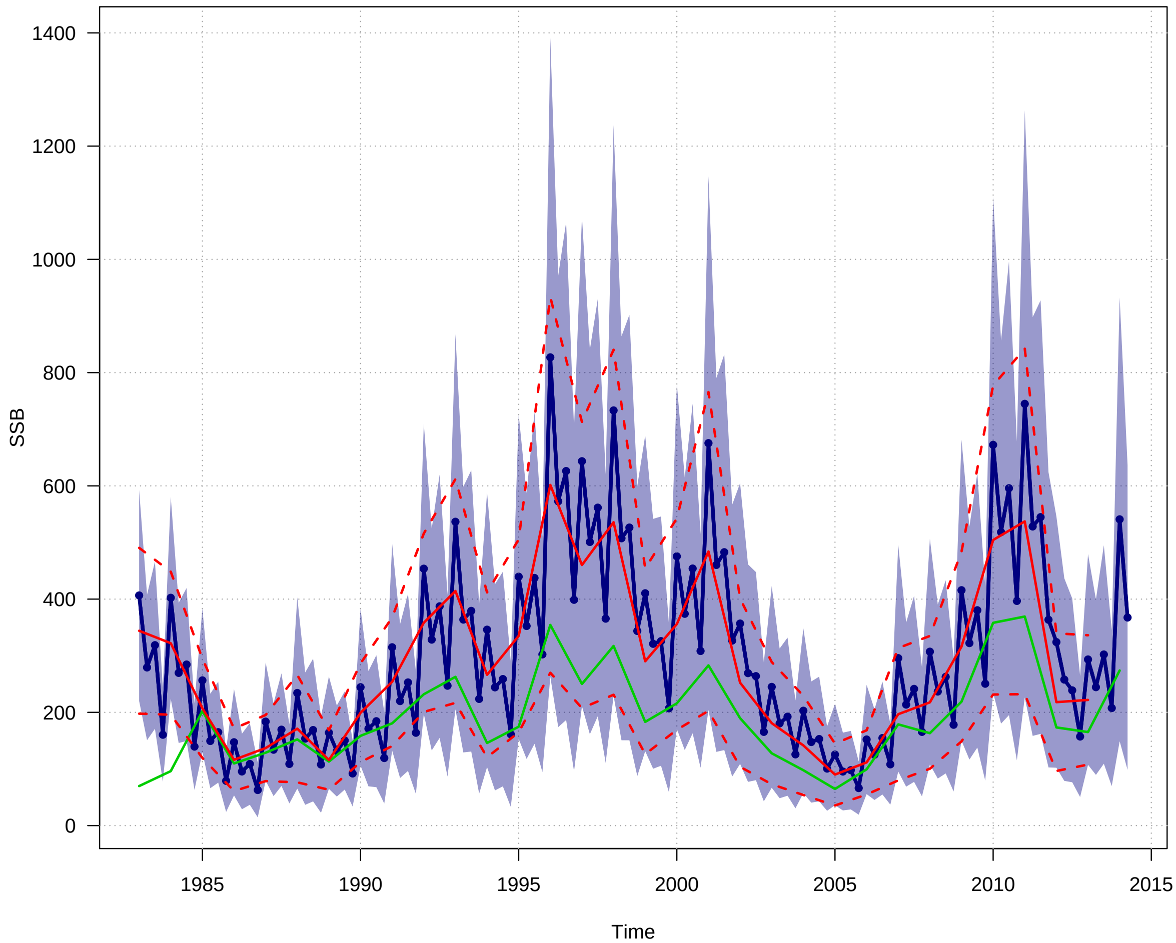


Figure 64: **run 9** SSB: Blue is SESAM, green is XSA (May 2014), red is the base run.

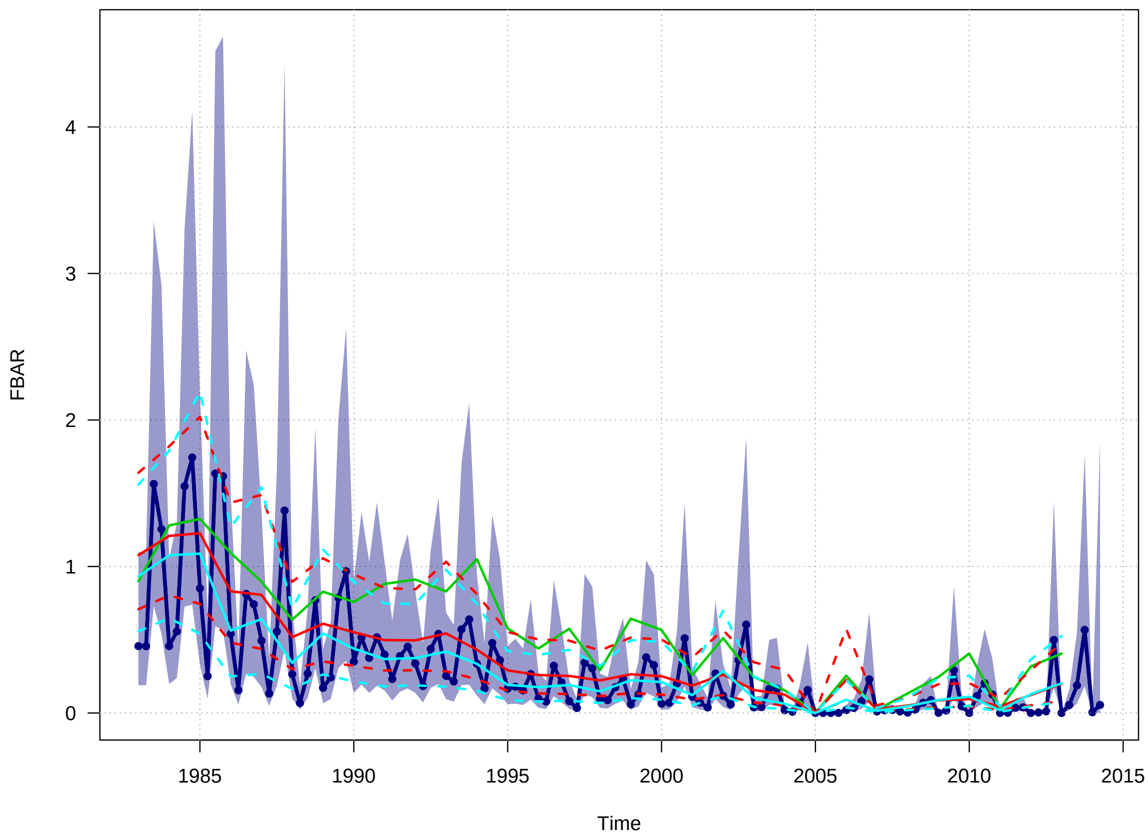


Figure 65: **run 9** $\bar{F}_{1-2}$: Blue is SESAM by quarter, cyan is SESAM yearly average, green is XSA yearly average, red is the base run.

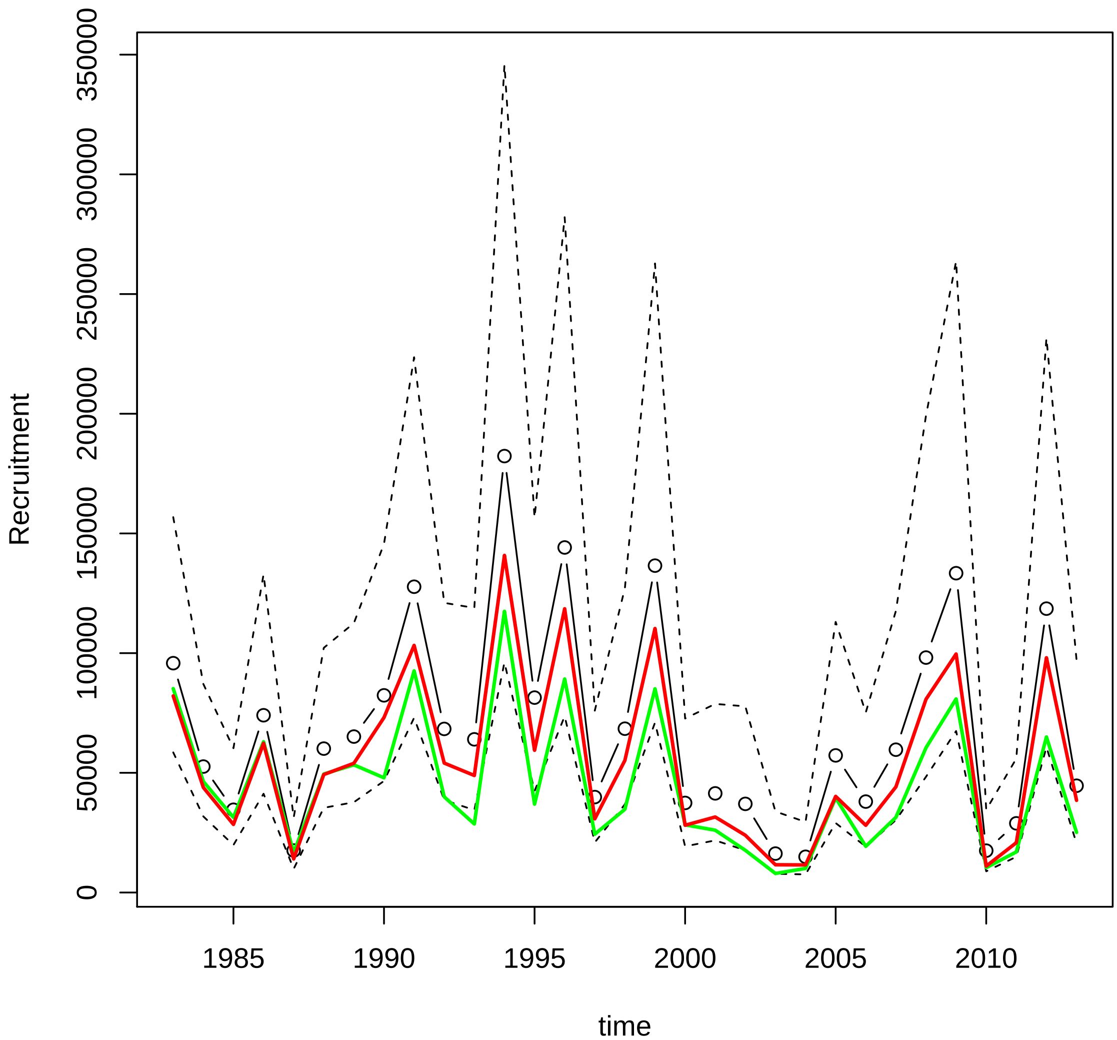
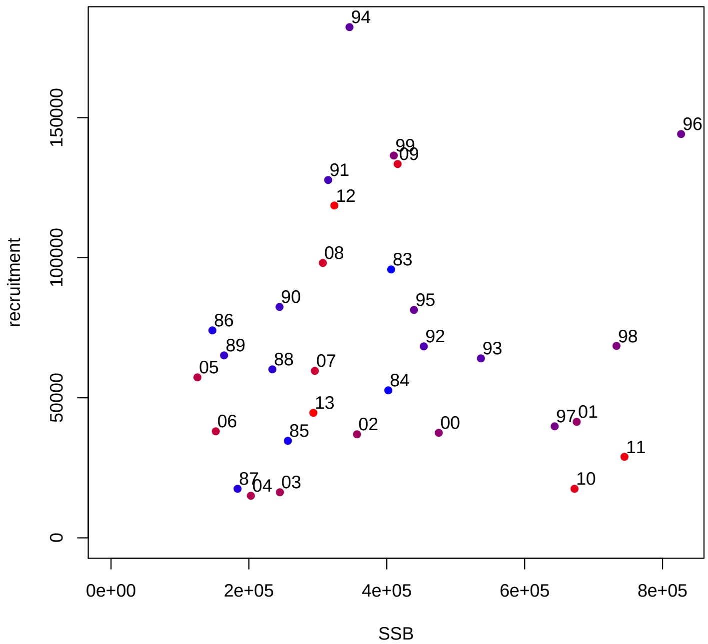


Figure 66: **run 9** Recruitment: Black is SESAM, green is XSA, red is the base run.



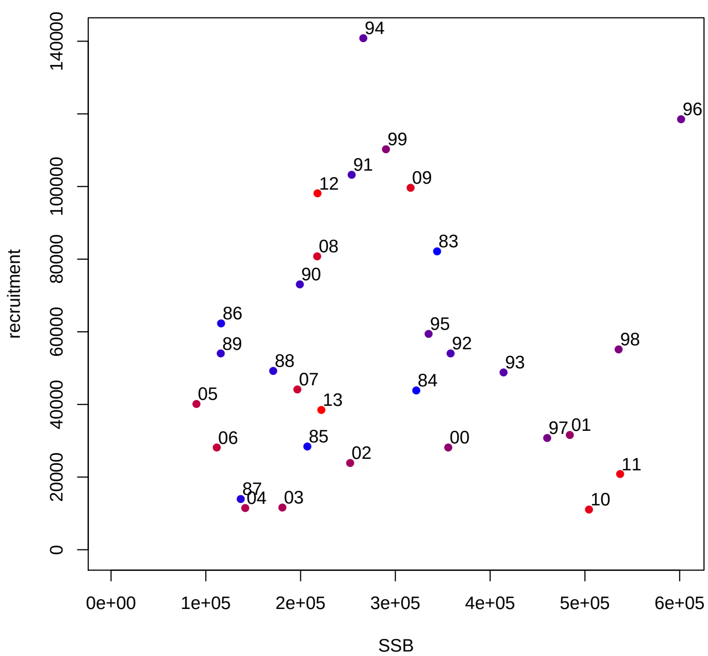


Figure 67: **run 9** Stock-Recruitment from SESAM (top). SSB is calculated in Q1, whereas recruitment is in Q3. Bottom figure is base run.

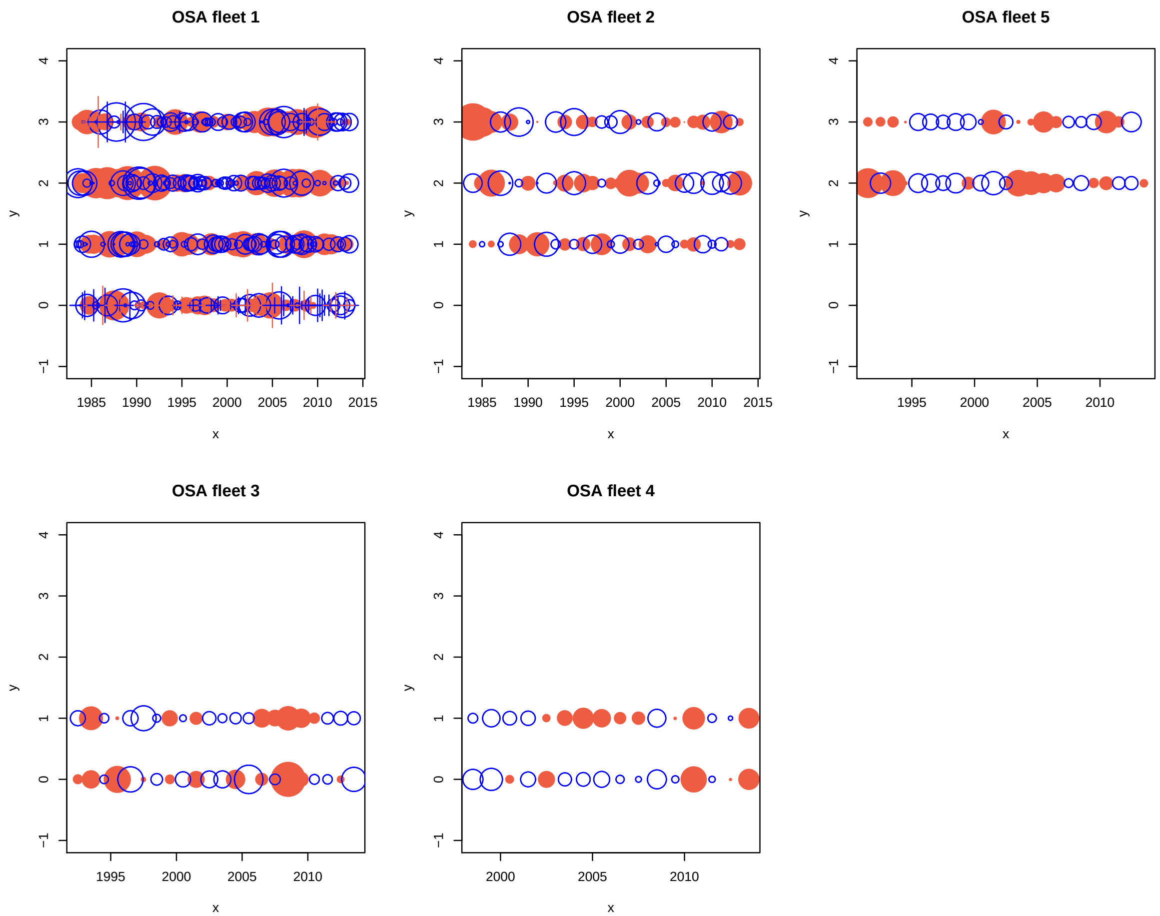


Figure 68: **run 9** SESAM one-step ahead residuals by fleet. Circles are used for positive observations while '+' denotes randomized residuals from zero observations. Blue is positive, red is negative.

	time	SSB	lo	hi
1	1983	406.47	253.20	559.74
2	1984	402.36	255.67	549.04
3	1985	256.50	151.95	361.06
4	1986	147.22	69.96	224.48
5	1987	183.65	97.72	269.59
6	1988	234.21	95.26	373.16
7	1989	164.13	82.49	245.77
8	1990	244.43	130.48	358.38
9	1991	314.96	164.82	465.11
10	1992	453.76	242.72	664.80
11	1993	536.63	264.13	809.12
12	1994	346.04	146.43	545.65
13	1995	439.58	203.96	675.21
14	1996	827.00	363.10	1290.91
15	1997	643.55	287.80	999.30
16	1998	733.30	318.82	1147.78
17	1999	410.34	180.94	639.73
18	2000	475.50	224.93	726.08
19	2001	675.49	287.90	1063.08
20	2002	356.86	153.01	560.70
21	2003	244.95	98.43	391.47
22	2004	202.87	83.18	322.57
23	2005	125.47	51.85	199.09
24	2006	152.09	72.74	231.43
25	2007	295.73	130.96	460.49
26	2008	307.20	143.26	471.13
27	2009	415.72	197.13	634.32
28	2010	672.46	312.44	1032.49
29	2011	744.87	318.40	1171.34
30	2012	324.09	141.59	506.58
31	2013	293.45	140.35	446.54
32	2014	540.93	218.54	863.32

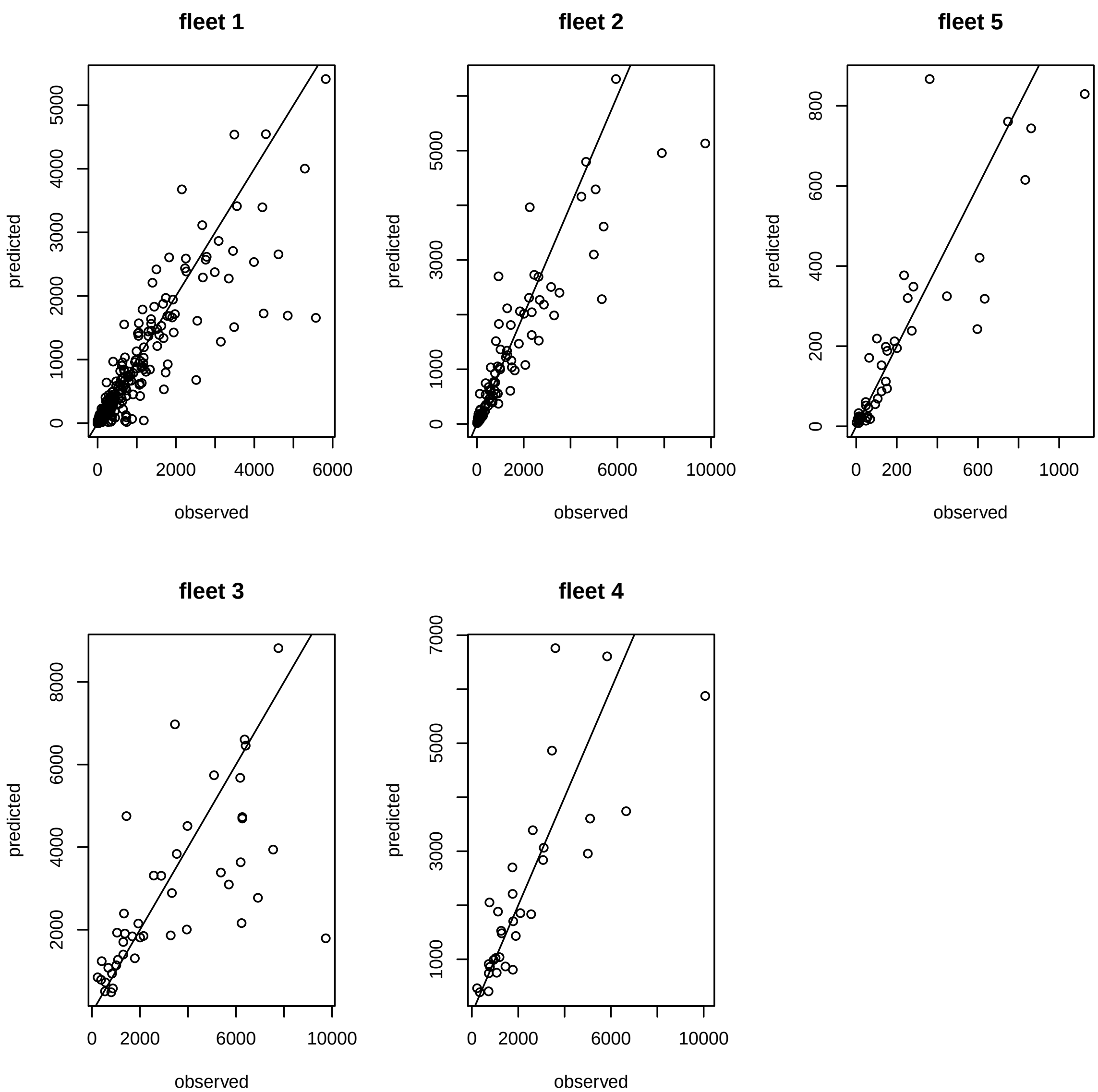
Table 34: SSB in Q1. 'lo' and 'hi' is the 5 and 95 percentiles respectively

	time	SSB	recruitment
1	1983.00	406.47	95812.31
2	1984.00	402.36	52622.97
3	1985.00	256.50	34586.21
4	1986.00	147.22	74053.26
5	1987.00	183.65	17555.23
6	1988.00	234.21	60126.45
7	1989.00	164.13	65153.40
8	1990.00	244.43	82376.82
9	1991.00	314.96	127751.51
10	1992.00	453.76	68354.53
11	1993.00	536.63	63997.50
12	1994.00	346.04	182320.51
13	1995.00	439.58	81429.79
14	1996.00	827.00	144140.94
15	1997.00	643.55	39878.44
16	1998.00	733.30	68446.17
17	1999.00	410.34	136558.40
18	2000.00	475.50	37437.55
19	2001.00	675.49	41426.71
20	2002.00	356.86	37045.24
21	2003.00	244.95	16281.26
22	2004.00	202.87	14940.67
23	2005.00	125.47	57281.62
24	2006.00	152.09	37999.37
25	2007.00	295.73	59671.27
26	2008.00	307.20	98158.54
27	2009.00	415.72	133395.86
28	2010.00	672.46	17500.44
29	2011.00	744.87	28906.59
30	2012.00	324.09	118590.65
31	2013.00	293.45	44624.34

Table 35: Estimated SSB in Q1 and recruitment in Q3

	time	fbar	fbar5	ssb	ssb5
1	2014.25	0.06	0.02	388.98	211.01
2	2014.50	0.19	0.08	425.27	225.91
3	2014.75	0.59	0.23	274.21	137.12
4	2015.00	0.01	0.00	341.75	175.01
5	2015.25	0.06	0.02	271.33	138.28
6	2015.50	0.19	0.08	282.98	140.90
7	2015.75	0.59	0.23	186.49	89.29
8	2016.00	0.01	0.00	298.48	134.02

Table 36: Forecast given status quo F. 'fbar5' and 'ssb5' are the 5th percentiles



[!htb]

Figure 69: **run 8** Observed versus predicted.

	time	fbar	fbar5.0	ssb	ssb5
1	2014.25	0.00	0.00	389.83	211.72
2	2014.50	0.00	0.00	434.05	233.69
3	2014.75	0.00	0.00	298.79	157.32
4	2015.00	0.00	0.00	406.63	232.33
5	2015.25	0.00	0.00	320.32	179.56
6	2015.50	0.00	0.00	339.47	185.18
7	2015.75	0.00	0.00	233.92	124.07
8	2016.00	0.00	0.00	403.73	191.75

Table 37: Forecast given zero F. 'fbar5' and 'ssb5' are the 5th percentiles

Parameter estimates

	Estimate	Std. Error
logSdLogFsta	0.5225184	0.08094524
logSdLogN	-2.0487090	0.96866392
logSdLogObs	0.8598290	0.07435483
logSdLogObs	-0.5045405	0.09543755
logSdLogObs	-0.6569763	0.09347905
logSdLogObs	-0.5142971	0.12031938
logSdLogObs	-0.8105399	0.15220142
logSdLogObs	-0.4539778	0.12080368
logQ	-2.6282446	0.25059190
logQ	-2.1102179	0.29149656
logQ	-2.2412425	0.40971581
logQ	-2.8541428	0.29536758
logQ	-2.0728556	0.30397908
logQ	-2.7874268	0.30059608
logQ	-2.2501052	0.30792043
logQ	-2.2468620	0.35559650
logQ	-3.1728541	0.41659265
trans_rho	2.4627419	0.40159986
logSdLogR	-0.1191183	0.15603907
rho	0.9855862	0.01149372

References

Berg, C. W. and Nielsen, A. (2016). Accounting for correlated observations in an age-based state-space stock assessment model. *ICES Journal of Marine Science: Journal du Conseil*, page fsw046.

Cadigan, N. G. (2015). A state-space stock assessment model for northern cod, including under-reported catches and variable natural mortality rates 1. *Canadian Journal of Fisheries and Aquatic Sciences*, 73(2):296–308.

Ferro, R., Özbilgin, H., and Breen, M. (2008). The potential for optimizing yield from a haddock trawl fishery using seasonal changes in selectivity, population structure and fish condition. *Fisheries Research*, 94(2):151–159.

Nielsen, A. and Berg, C. W. (2014). Estimation of time-varying selectivity in stock assessments using state-space models. *Fisheries Research*, 158:96–101.

4 Appendix

4.1 Parameter names

Name	Description
logSdLogFsta	log of process CV for $\log F$
logSdLogN	log of process CV for $\log N$ (survival process)
logSdLogObs	log observation CV. Estimates and their ordering correspond to the 'keyVarObs' coupling.
logQ	log catchability (surveys only). Estimates and their ordering correspond to the 'keyLogQ' coupling.
trans_rho	correlation between increments in the $\log F$ for neighbouring age groups (on transformed scale)
logSdLogR	log of process CV for log recruitment function.
rho	same as 'trans_rho' except on the normal scale (i.e. between -1 and 1).

4.2 Coupling of parameters

Rows denote fleets (if multiple), columns are ages.

```
$keyVarObs
     [,1] [,2] [,3] [,4]
[1,]    0    1    1    0
[2,]    2    3    3    2
[3,]   NA    4    4    4
[4,]    5    5   NA   NA
[5,]    6    6   NA   NA
[6,]   NA   NA    7    7

$keyVarLogN
[1] 0 0 0 0

$keyLogFsta
[1] 0 1 2 3

$keyVarLogF
[1] 0 0 0 0

$keyLogQ
     [,1] [,2] [,3] [,4]
[1,]   NA   NA   NA   NA
[2,]    0    1    2    3
[3,]   NA    4    5    6
[4,]    7    8   NA   NA
[5,]    9   10   NA   NA
[6,]   NA   NA   11   12
```

Name	Description
keyVarObs	observation variance coupling
keyVarLogN	survival process variance
keyVarLogF	F-process variance coupling
keyLogQ	catchability coupling

4.3 Simulation study

The results from the simulation study are shown in figure 70. The true simulated state trajectories (log(N) and log(F)) are generally within the confidence bounds of the estimated trajectories as expected. The confidence intervals for the estimated fixed effect parameters also appear to have the right coverage, so the conclusion must be that the simulation code correctly correponds to the estimation code and the model is identifiable from the data.

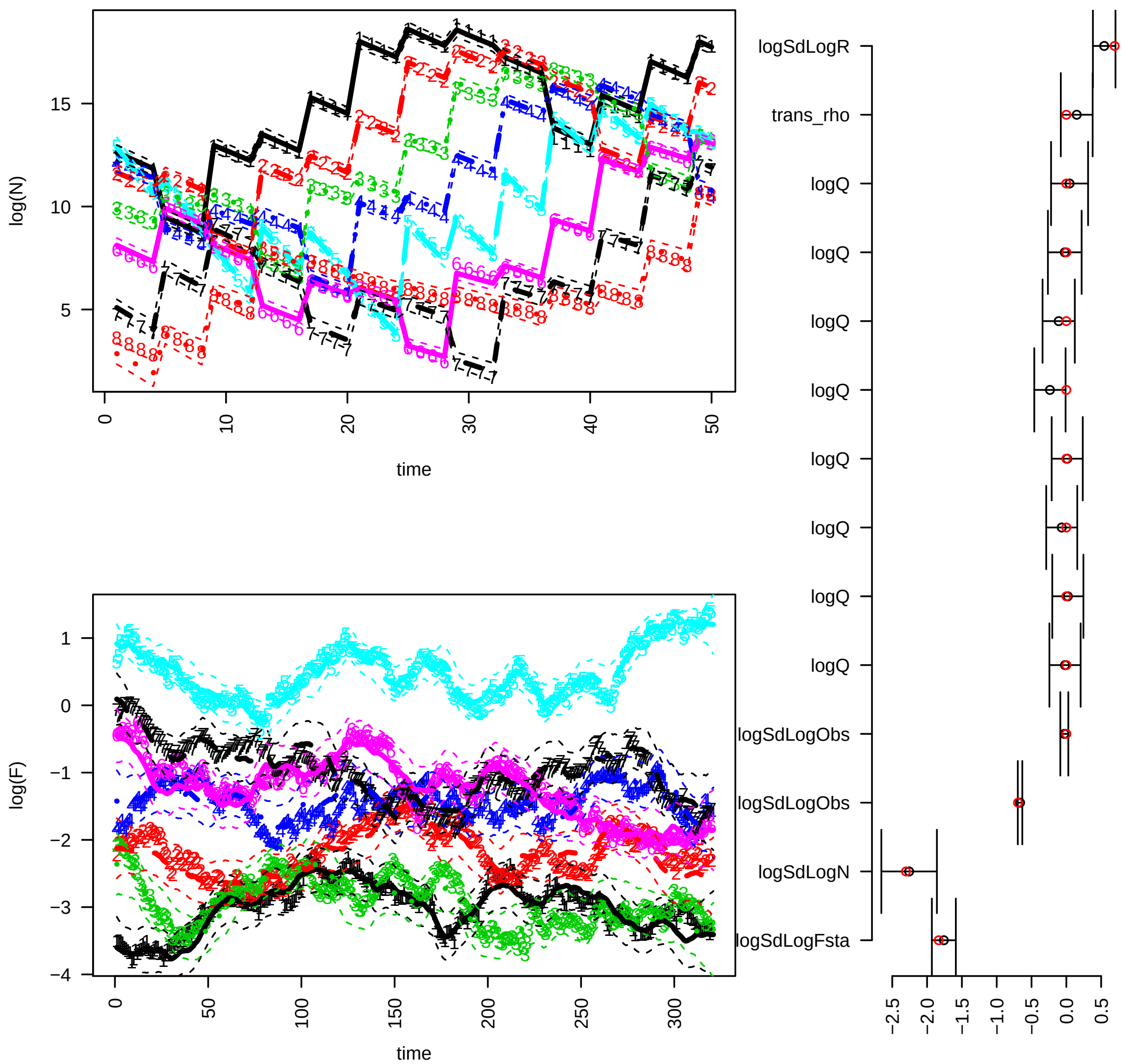


Figure 70: Results from simulation study. Excerpt of true and estimated log-transformed stock numbers, log(N), by age over time (quarterly timesteps, only first 50 are shown), log-transformed fishing mortalities by age, log(F), (ages 7 and 8 have been grouped together), and parameters (right panel, true values shown as red dots). On all figures 95% marginal confidence intervals are shown, and on the figures with log(N) and log(F) true values are shown as numbers, and estimated values are shown as thick lines with thin dashed lines indicating CIs.

Annex 4: DCWKPOUT Report

Data Evaluation Workshop: DCWKPOUT

18–19 May 2016, ICES HQ, Copenhagen

Conduct of meeting

The data evaluation workshop DEWKPOUT was held at ICES HQ, Copenhagen over the period 18–19 May 2016. The Terms of Reference, Agenda and List of Participants are given in Appendix 1 (of this Annex). The presentations covered the Norway pout assessment and available data, as well as issues to be investigated by the benchmark. Cpue data requested in the data call were presented for both Norway and Denmark. The Industry was requested to provide information from the fishery, and this is reflected in Appendix 2 (of this Annex).

Presentations

The first presentation (Rasmus Nielsen) provided a summary of the most recent Norway pout assessment (input data, model structure and results) and the advice that resulted from it. There was a brief summary of the long-term management strategy evaluation work that has been carried out on the stock since 2007. There was some discussion on the survey indices, particularly in relation to the 2014 year class, which appeared to strong at age 0 and age 1 in the EGFS Q3 and SCFS Q3 surveys, and the IBTS Q3 survey, and at age 1 in the IBTS Q1 survey, but seems to be much weaker at age 2 in the IBTS Q1 survey, confirming reports from the Industry that they were finding these fish in 2015 (and would have caught them to a greater extent during 2015 were it not for good sprat abundance to which fishing effort was diverted), but not in 2016. The presentation then gave a brief summary of the 2012 benchmark, and described plans for the 2016 benchmark in more detail:

1) Assessment method (Seasonal SXSA -> Seasonal SAM);

2) Consider new MSY reference levels given:

   2.1) changed assessment year;

   2.2) new assessment model;

   2.3) 5% risk of being below B_{lim} and above F-Cap in stochastic forecast;

   2.4) mean recruitment used in forecast year; and

   2.5) in ecosystem/multispecies context.

3) Consideration of commercial fishery data time-series and general trends in commercial cpue data according to period/year, season, area, country, use of selective devices (trawl grids) and industrial fishery HP classes;

4) Test age-reading data: Age-reading tests and check between samples from the fishery in Denmark and Norway, respectively.

The second presentation (Rasmus Nielsen) looked at the landings data in more depth (by area, quarter, métier), and in particular plotted the Danish landings and cpue data by quarter and ICES rectangle for selected years (1987, 2000, 2013). The spatial placement of some of the data led to questions being raised by the Danish Industry about the veracity of the data (e.g. some apparently occurring in closed areas, and others in areas not known for Norway pout fishing).

The third presentation (Espen Johnsen) provided some background information from the Norwegian Norway pout fishery, covering regulations (use of selection grids and area restrictions) and changes in the fleet (e.g. declining use of grids as more vessels are equipped to handle larger fish for human consumption, and increasing use of twin trawls by larger vessels). A comparison of quarterly trawl positions (from logbooks) for vessels with and without sorting grids for the period 2011–2015 was also provided.

Issues raised

Catch data prior to the mid-1990s

Doubts were raised about the reliability of catch data prior to the mid-1990s (the introduction of the Danish industrial bycatch sampling programme improved reporting for Danish landings from 1995 onwards), because of the potential for bycatches of other species to be reported as Norway pout. There was a suggestion that a truncated period of catch data (1995 onwards only) should be considered for the assessment. However, it was pointed out that a substantial amount of work on this issue was done in the past, through groups such as the Industrial Fisheries Expert Group, and through EU-Norway negotiations (~2004/2005) that led to the decision for using a catch time-series from 1983 onwards, which were the best data that ICES could provide. Furthermore, the Norwegian Norway pout fishery has always been a mixed fishery with bycatches allowed, so Norwegian landings prior to the mid-1990s may have been reasonably reliable (because of the lack of incentive to misreport). In the absence of substantiated information presented to the workshop that challenges the decision made in the past to use the catch data from 1983 onwards, the workshop supports the continued use of the catch data from 1983 onward in the assessment. A working document summarising the past work on this issue, supporting the use of 1983 onwards catch data in the assessment, will be presented to the benchmark meeting.

Danish landings and cpue

As noted in the presentation summaries above, doubts were raised about the veracity of Danish landings and cpue from some areas, in particular south of ~56°N, and whether these were misreported by species or by area (or both). It was decided that further investigation was needed:

- on the basis of available sampling, catch compositions should be checked to investigate the potential for species misreporting;
- through the analysis of trip length information, the feasibility of area assignment can be checked to investigate the potential for area misreporting.

Cpue currently used in the assessment

Questions were raised about the earlier cpue data (1983–2004, 2006) currently used in the assessment, particularly given the potential problems with species and/or area misreporting in the Danish data highlighted above, and also the double-use of the same age information in both the catches and cpue data (leading to greater weight being given to these data in the assessment because of their close agreement). Sensitivity analysis was proposed to deal with this, with the final decision about whether to include these data in the assessment resting with the benchmark. It was also suggested that an effort time-series may provide a useful, independent proxy for fishing mortality to compare with assessment estimates (under the assumption of a linear relationship between effort and fishing mortality).

Norwegian cpue

Since 2011, data from logbooks for the Norwegian Industrial trawlers have been reported electronically, and Norwegian cpue data were presented for the period 2011–2015. It was argued that the cpue data were not suitable for inclusion as a tuning series in the assessment because of the difficulty of defining what is being targeted, given the mixed fishery nature of Norwegian Industrial trawlers. However, cpue and effort time-series should be presented in order to follow the nature and development of the fishery. To calculate effort and cpue for years before 2011, VMS data may be merged with Norwegian landings statistics, but preliminary analyses show that it is very difficult to identify and estimate Norway pout fishing days. Due to these problems, the Workshop recommends that Norway should establish cpue and effort time-series based on logbooks available from 2011 onwards. The Workshop also recommended that effort should be grouped in intervals of 500 horse power, because intervals of 100 horse power may consist of single vessels which will no longer be anonymous.

Discard information

These are now available through InterCatch, and should be included in the assessment.

Recommendations for WKPOUT

- Keep current datasets (current catch, current historic cpue and current IBTS Q1, Q3 and UK-Q3-EGFS and UK-Q3-SGFS) and develop SAM assessment:
  - Check whether discards can be included or not (include if yes);
  - Keep SXSA assessment as an alternative assessment for comparison at the benchmark.
- Develop forecast methodology;
- Develop MSY and PA reference points (including ecosystem considerations);
- Conduct sensitivity analyses:
  - Remove historic commercial cpue from the assessment.
- Compile time-series of effort and compare to changes in F:
  - Norwegian and Danish data available.

Working Documents to be expected for WKPOUT

1) Seasonal SAM assessment development, including 3–5-year back comparison with SXSA, and sensitivity analysis [led by Rasmus Nielsen].

2) Forecast methodology, and MSY and PA reference points, including implications of sensitivity analysis and ecosystem considerations [led by Rasmus Nielsen].

3) Norwegian fishery description and cpue analysis [led by Espen Johnsen].

4) Danish fishery description and cpue analysis [led by Rasmus Nielsen].

5) Existing supporting documents on historic catches (Industrial fisheries Expert Group, EU-Norway negotiations) [coordinated by Rasmus Nielsen].

6) Age-reading data comparisons [coordinated by Rasmus Nielsen].

7) Norwegian Shrimp survey estimates east of Norwegian trench (comparing perceptions with IBTS surveys), as supplementary information only (not as a tuning series) [led by Espen Johnsen].

Appendix 1 to Annex 4

Terms of Reference, Agenda, List of Participants

Terms of Reference

Conduct a three day data evaluation workshop. Stakeholders are invited to contribute data (including data from non-traditional sources) and to contribute to data preparation and evaluation of data quality. As part of the data evaluation workshop consider the quality of data including discard and estimates of misreporting of landings;

Following the data evaluation correspondence work, produce working documents to be reviewed during the Benchmark meeting; these documents should be available at least seven days prior to the meeting.

Agenda

1) Introductions;
2) Summary of the current Norway Pout assessment and input data;
3) Presentation of benchmark issues;
4) Presentation of new commercial cpue data (Danish and Norwegian);
5) Any further data from Industry;
6) Any other data issues relevant to the assessment;
7) Working documents to be prepared for WKPOUT in August.

Wednesday, 18th May

10:00–13:00

14:00–17:00

Thursday, 19th May

09:00–13:00

List of Participants

Rui Catarino (ICES Secretariat)
José De Oliveira (Chair, UK)
Espen Johnsen (Norway)
Jesper Juul Larsen (Denmark)
Henrik S. Lund (Denmark)
Rasmus Nielsen (Denmark)
Søren Anker Pedersen (Denmark)
Claus Reedtz Sparrevohn (Denmark)

Appendix 2 to Annex 4

Information and data from the industry

Why is the quota not taken?

Denmark

- Economic considerations (fuel, time; for 2015, it was easier to catch sprat)
- Fishing opportunities (prices of renting quota)
- Few vessels left in the fishery
- Restricted area for Norway pout fishing
- Sprat quota affected fishing for Norway pout

Norway

- Few vessels are specialist
- Economic considerations
- Small vessels (<40 m) have combined blue whiting-Norway pout quota
- Very few large vessels (>60 m), because the catch rates with low trawl (i.e. gear needed for Norway pout fishing to avoid bycatch) cannot support the cost

Information to be included in WD on fishery descriptions

Why can't you find the Norway pout?

- Not relevant; can be found if fished for
- Cpue for Danish fishing was satisfactory for 2015
- Acoustic observations of high abundance in Norway pout box in 2015

Changes in the fishing patterns in the last 10–15 years

Change of gears?

- No general change of the gears (DK, N), although there have been changes in design that affect door contact with the bottom (DK); improvements in technology over time (N only)
- Use of grid from 2012 (DK, all vessels), and from 2010 for some vessels (N)
- Potential changes from 2016 to twin trawls for some vessels (for both DK and N)

Selective devices (grids) in which type of fishery?

- For Norway, six vessels have a licence to fish without the grid, and still fish with the same gear

Change in vessel sizes (larger vessels)?

- When fishing is very good, a few very large pelagic vessels switch to Norway pout fishing; also depending on other fishing opportunities (DK only); large proportion of larger Norwegian vessels are also entering the fishery depending on opportunities

Individual quota (which fleet type)?

- A large proportion of the quota (56%) in Denmark is owned by the Pelagic fleet. Only in certain situations do they fish it themselves (e.g. good Norway pout fishing), otherwise the quota is rented out. This has not been restrictive for the traditional fishery.
- There is a vessel quota in Norway for those vessels that have a licence.

Renting out quotas to which fleets?

- Explained above.

Change in species and size/age targeting?

- Species targeting influenced by economic considerations and fishing opportunities. For example, nowadays there is switching between sprat and Norway pout, whereas previously (in the 1970s) there was switching between whiting, sprat and Norway pout

Changes in fishing seasons?

- No change for Danish fishing fleets (mainly 1 August–31 December); other periods have been attempted, but catch rates have been poorer; previous Q1 fishing was a combined human consumption and Norway pout/Blue whiting fishery
- Norwegian season mainly from June–December (some effort in April–May)

Changes in fishing area?

- Danish vessels no longer fish in Norwegian waters, but this could be changed due to EU-Norway negotiations
- For Norway, from 2002 onwards, the Patch Bank was closed, and from 2003 onwards, the Egersund Bank is closed every year for the period 1 October–31 May. These closures were to reduce the bycatch of gadoids and herring.

Changes (including in fishing behaviour) resulting from changes in regulations?

- Yes
- For Denmark, the two major changes are the landings obligations from 2015 and introduction of the grid from 2012. The landings obligations means the catch composition rules no longer apply, except for gadoids. The target species regulations have changed over the years (described in detail in stock annex for Norway pout). All these changes in regulations have meant changes in catch composition and targeting behaviour. The introduction of the grid has led to a reduction in catch rates of 5–10%. The grid reduced the bycatch of gadoids by around 50% in biomass, but it remains difficult to avoid small gadoids (Eigaard *et al.*, 2013, Fisheries Research); it also resulted in a reduction of herring bycatch.
- For Norway, area closures have had an effect. Introduction of the grid has had an effect on bycatches, but some vessels do not always use it.

Other issues

The Danish fishing industry state that catches are cleaner (contain less bycatch) during night-time, because herring rise off the bottom at night. Catch rates of Norway pout are higher during the day compared to night. Furthermore, bycatches of gadoids are also reduced at night, but the reason for this is unclear. To make the Norway pout fishery economically sustainable, fishing occurs both through the day and night.

Annex 5: Updated Stock Annex

The table below provides an overview of the WGNSSK stock annex WKPOUT has updated. Stock Annexes for other stocks are available on the ICES website Library under the Publication Type "Stock Annexes". Use the search facility to find a particular Stock Annex, refining your search in the left-hand column to include the *year*, *ecoregion*, *species,* and *acronym* of the relevant ICES expert group.

Stock ID	Stock name	Last updated	Link
nop.27.3a4	Norway pout in the North Sea and Skagerrak (ICES Area 4 and 3.a)	May 2017	Norway Pout