Stock Annex: Whiting (*Merlangius merlangus*) in Division 3.a (Skagerrak and Kattegat)

Stock specific documentation of standard assessment procedures used by ICES.

Stock:	Whiting in Division 3.a
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A. General

A.1. Stock definition

There is a paucity of information on the population structure of whiting in 3.a (the Skagerrak-Kattegat area). A population separation between the North Sea and the 3.a has been observed for gadoids such as Atlantic cod (*Gadus morhua*) and haddock (*Melanogrammus aeglefinus*; e.g. Knutsen *et al*. 2004; Svedäng *et al*. 2007; 2010; Cardinale *et al*. 2012), as well as for herring (*Clupea harengus*; Ruzzante *et al*. 2006) and plaice (*Pleuronectes platessa* Ulrich *et al*. 2013). No genetic surveys have been conducted, nor otolith-based surveys. Tagging of whiting have previously been made, yet these data need to be re-examined. Results from modelled survey data (SURBAR) are inconclusive regarding independent population dynamics in 3.a in comparison with the North Sea. The decrease in landings in the beginning of the 1990s gives however an indication of local stock structure, as this reduction was not paralleled by any similar event in the North Sea nor in existing surveys, thus giving a support for a stock separation between the North Sea and 3.a.

A.2. Fishery

Landings

The total landings of whiting from 3.a have declined from over 20 000 tonnes in the 1980s (>40 000 tonnes in single years) to 372 tonnes in 2018, including both human consumption and industrial bycatch. It remains unclear to what extent the drastic reduction in landings was due to a decline in the whiting stock biomass in 3.a or to changed fishing patterns. Denmark is responsible for most of the landings in the area, followed with significantly less landings from Sweden and Norway. The industrial fleet is landing most of whiting in the area followed by otter trawls; whiting is mostly discarded for all fleets except the small mesh industrial fleet.

Discards

Discard rates were obtained from samples provided by Denmark and Sweden, where a discards sampling programme has been carried out since 2002. The discard coverage is relatively high and around 80-90% of the landings (by weight) have discard information. ICES estimates of discards are 1334 tonnes in 2018 which corresponds to 78.2% of the total catch (1706 tonnes).

A.3. Ecosystem aspects

Understanding the complex mechanisms linked to the temporal and spatial distribution of fish abundances play a central role in ecosystem functioning and dynamics. The analysis of a time series of juveniles whiting along the Norwegian coast in the Skagerrak (Frometin *et al*. 1997) from 1919 to 1994 provided useful information on the spatial variability of this species related to both biotic and abiotic factors. The recent decline of this population may be also related to a decline of *Calanus finmarchicus* that constitutes an important food resource for the fish larvae (Fromentin & Planque 1996; Planque & Fromentin 1996).

The size structure and abundance of this species along the Swedish Skagerrak coast (Svedäng 2003) showed a distinct shift in the size spectra to smaller sizes in comparison with the historical time series between the 1920's to 1970's. Historical survey data (described in Cardinale *et al*. 2010) showed relatively much higher abundance of large sized whiting between the 1920´s and 1950´s in the 3.a than in the time period thereafter (Hagberg 2005).

A.3. Biology

Whiting is a major prey component of the diet of many piscivorous fish and marine mammals. The spatial distribution of whiting in the neighbouring North Sea is considered to have changed over the last decade. This may represent a contraction to a substock structure coinciding with the main spawning areas in the North Sea. Spawning occurs from January to July at 30–100 m depth. Whiting attain sexual maturity at age 2–3 years (50% point of the maturity ogive is about 21.5 cm). Maximal recorded length 70 cm, maximal age 20 years.

B. Data

B.1. Commercial catch

The new data available for this stock are too insufficient to undertake an assessment of this stock. Due to the uncertain nature of stock status the advice was revised. The commercial landings for this stock are available from 1975 to present, and estimate of discards from 2002 to present. Additional landing information is available as part of the ICES official nominal catches database.

The estimation of discards is done using InterCatch data. Discards for unsampled strata are raised, assuming the discard rate to be equal to a weighted mean of reported discard rates. The weights are equal to the total landings in tonnes. The raising is done by grouping all fleets by area. The industrial fleet, responsible for a substantial part of the landings (42% in 2018) and the Norwegian fleet are assumed to have no discards.

B.2. Biological

Length distributions are available for the stock. Whiting catches are sampled and measured in the human-consumption fleet. The sampling of the industrial fleet is very limited (few hundred individuals per year), leading to length frequency distributions that are not representative of the catch or the stock.

B.3. Surveys

There are four bottom trawl surveys that are relevant to estimate biomass indices for whiting in the area, namely the two international bottom trawl surveys (NS-IBTS and BITS) and two Danish national bottom trawl surveys targeting cod and sole (Figure 1).

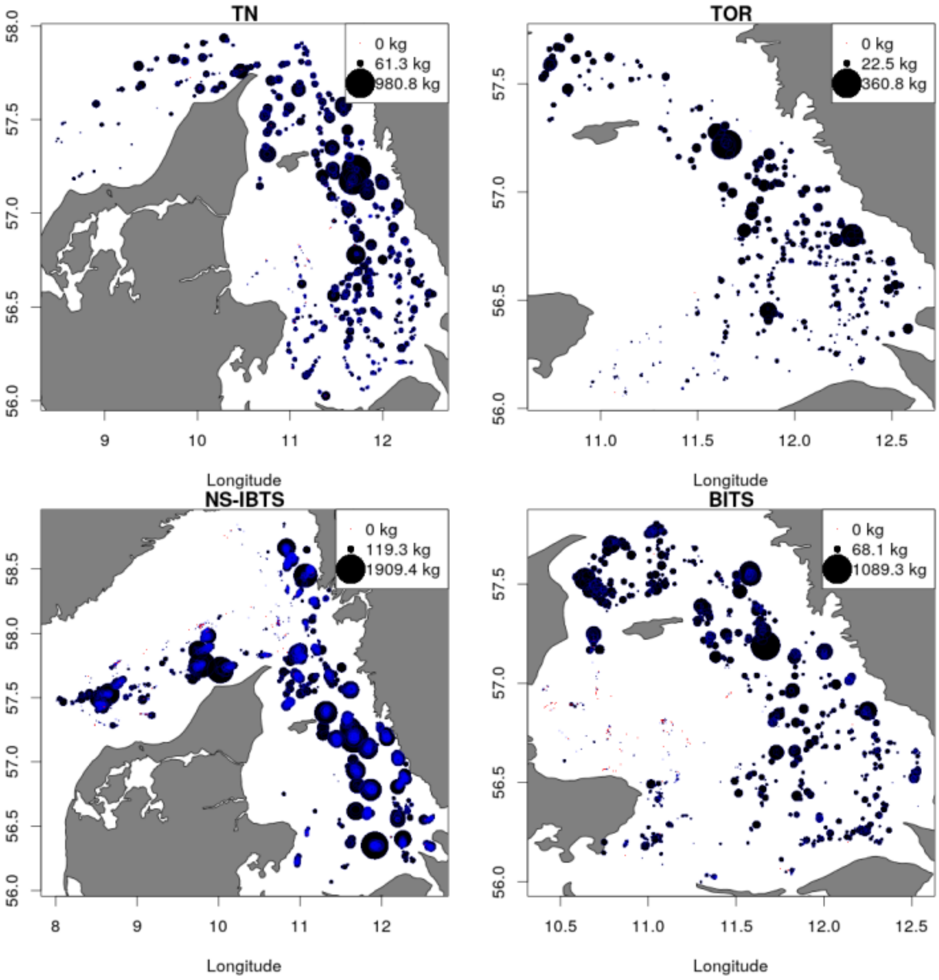

Figure 1. Stations of the four scientific surveys that are included in the calculation of the biomass index of whiting in Division 3.a. The two Danish national surveys targeting sole (TN) and cod (TOR), and the two international bottom trawl surveys in the North Sea (NS-IBTS) and the Baltic Sea (BITS). The size of the points corresponds to total catch of whiting in each haul in kg. The extend of each survey and the scaling of the points differ for each survey.

NS-IBTS

The North Sea international bottom trawl survey (NS-IBTS) covers most of ICES Division 3.a. The survey includes Skagerrak and Kattegat since 1969. The GOV trawl was introduces as standard gear and the gear rigging and fishing methods were standardised. Since 1983, all participants are using the GOV trawl in Q1 and since 1992 in all quarters. The calculation of the whiting biomass index includes the all hauls taken using the GOV gear, i.e. Q1 from 1983 onward, Q3 from 1991 onward, and Q2, Q4 for the years 1991—1996. The number of hauls is around 46 in Q1, Q2 and Q3, but much lower in Q4. Data are available in the ICES DATRAS database.

BITS

The Baltic international trawl survey (BITS) was standardised among all participating countries in the mid-1990s. The gear that is used the most Skagerrak and Kattegat is the TVS (TV3#520), therefore only hauls using that gear are included in the index calculations. Data from 1993 for Q1 and 1996 for Q4 are included. Around 26 hauls in each quarter are included in the index calculation. Data are available in the ICES DATRAS database.

Danish national surveys

There are two Danish national surveys targeting cod and sole. The cod survey covers only Kattegat and is conducted in Q4 since 2008 with around 40 hauls per year. The sole survey covers both Skagerrak and Kattegat since 2004 with around 100 hauls per year. Both surveys use otter trawls, OTB in the cod survey and OTT in the sole survey. The data are made available by DTU Aqua.

Survey index

The survey index is calculated using an adapted version of the method described in Berg et al. (2014). The main differences include that the total catch in weight is modelled instead of numbers-at-age and that instead of a time invariant spatial effect, the model used here allows for smooth changes in the spatial distribution over time. The survey index is calculated using predictions from a Tweedie Generalised Additive model that is described by the following equation

$$\log(\mu i) = Gear(i) + f_1(lon_i, lat_i) + f_2(timeOfYear_i, lon_i, lat_i) + f3(time_i, lon_i, lat_i) + f_4(depth_i) + U(i)_{ship:gear} + \log(HaulDur_i)$$

that includes a spatial effect (f_1), a seasonal repeating pattern (f_2), a space-time interaction effect (f_3) that can capture smooth changes over longer time scales, a smooth function of depth (f_4), a fixed gear effect and random effects for the interaction between ship and gear. Finally, the model includes an offset term of the logarithm of haul duration that corresponds to the assumption that catch is proportional to haul duration.

The fitted model is used to predict expected catches over a fine grid with nuisance parameters set to constant values; the sum of all predicted values for each year and quarter gives the survey index.

The analysis is done using the R packages *surveyIndex* (Berg, 2020) and *DATRAS* (Kristensen and Berg, 2019).

C. Advice

During the last Benchmark of whiting in Division 3.a in 2020 (WKDEM 2020), the stock was raised from ICES category 5 to category 3 that includes stocks that have a survey index indicative of stock biomass trends (ICES, 2018). The advice on fishing opportunities will be based on the "2-over-three" rule, using the Q1 biomass index time series. Thus, the advice for the coming year(s), $\boldsymbol{C_{y+1}}$, will be based on the most recent catch advice ($\boldsymbol{C_{y-1}}$), adjusted by the ratio of the average index of the latest two years to the average index of the three years prior, i.e.

$$\boldsymbol{C_{y+1}} = \boldsymbol{C_{y-1}} \frac{\sum_{i=y-2}^{y-1} \boldsymbol{I_i}/2}{\sum_{i=y-3}^{y-5} \boldsymbol{I_i}/3}$$

where $\boldsymbol{I_i}$ is the Q1 biomass index in year i.

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