Stock Annex: Turbot (*Scophthalmus maximus*) in Division 3.a (Skagerrak and Kattegat)

Stock specific documentation of standard assessment procedures used by ICES.

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A. General

A.1. Stock definition

Turbot (*Psetta maxima* L.) is distributed in ICES Area 3.a (Skagerrak and Kattegat). The stock has historically been composed by two major spawning components, one in the Eastern Skagerrak and the other in the southern part of the Kattegat (Cardinale *et al*., 2009). Nielsen *et al*. (2004) show a sharp cline in genetic differentiation when going from the low saline Baltic Sea to the high saline North Sea, where samples from Skagerrak and Kattegat are in the transition zone. This suggests that the Skagerrak and Kattegat populations are inherently different from the turbot in the North Sea. Over the period 2009–2012, a genetic study of turbot population structure all over the species' distribution area has been conducted using both neutral and gene-associated genetic markers by Vandamme *et al*. (in prep). The neutral marker panel confirmed a break-up between the Baltic and Northeast Atlantic clusters. Within the latter, a more detailed pattern of genetic differentiation could be observed, when gene-associated markers were also included in the analysis (results soon to be consulted on https://fishreg.jrc.ec.europa.eu/web/fisheries-genetics). Nevertheless, in the presence of strong natal homing, high residency and limited migration (see Section H1 for references and details) as is the case for turbot, the question whether populations (i.e. aggregation of adult fish during spawning) are genetically distinguishable is not crucial to the existence of self-sustaining population units and for management (Waples *et al*., 2008). Accordingly, the existence of separated spawning aggregations is a key factor regulating the dynamic of the populations (Svedäng *et al*., 2010) and thus they should be managed accordingly (Cardinale *et al*., 2011a).

A.2. Fishery

In the North Sea, turbot has been considered a highly prized fish ("prime") since the middle of the 1800s. Historically, it has been exploited within a multispecies fishery targeting turbot together with brill (*Scophthalmus rhombus*) and sole (*Sole solea*) (Mackinson, 2002). In 3.a, a target fisheries for turbot probably only occurred when the stock was large (i.e. before 1960s; Cardinale *et al*., 2009), while today turbot is only caught as bycatch in the trawl, trammelnet and gillnet fisheries, although due to its high economic value, targeting might occur in specific areas and seasons.

International landing series from 3.a between 1950 and 2010 are presented in Figure A.1. Over the period 1950–1989, these landings ranged around 300 t per year. The landings declined from over 300 t per year in 1989 to less than 100 t per year in 2011. Denmark landed on average 83% of the 3.a turbot. Other countries contributing to the total landings were - in descending order of importance - the Netherlands (mainly because of a peak in the second half of the seventies), Sweden, Norway, Belgium, Germany and the UK.

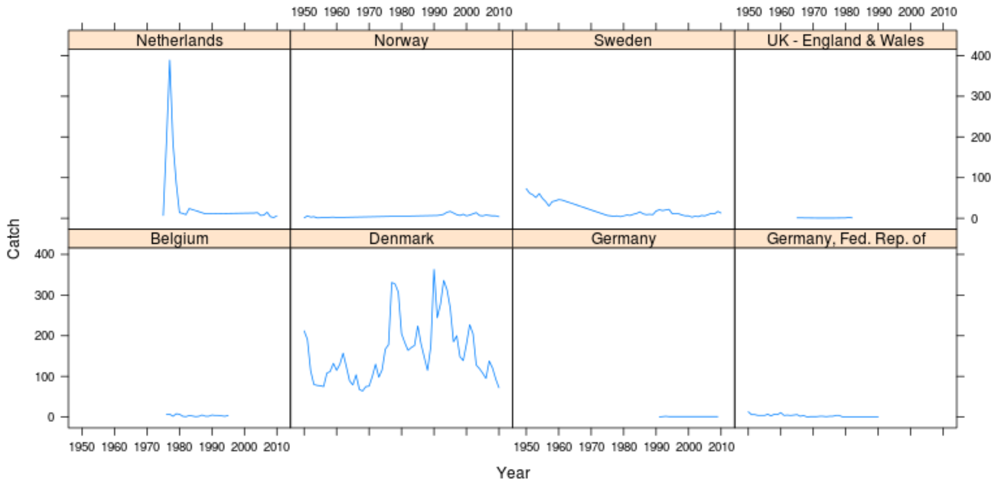

Figure A.1. Landings of turbot by country from 1950 to 2011 in 3.a. UK- Eng+Wales includes N. Ireland in 1991 (0.5 t), while Sweden reported aggregated catches for 3.a and 4.a+b in 1973 (9.0) and 1974 (7.0).

A.3. Ecosystem aspects

Discards: Discarding of turbot in 3.a is considered negligible due to the high value of the species. Also, survival rates of discarded turbot are likely to be high. A Minimum Landing Size of 30 cm (as independently installed by various authorities) leads to the landing of many immature individuals and in particular females, while increasing the MLS to higher lengths leads to higher discarding percentages.

B. Data

B.1. Commercial catch

Commercial catch data are obtained from national laboratories of nations exploiting turbot in 3.a. Landings data are available by countries since 1901 from official ICES sources. Information on the size structure of the catches might be available at the national laboratories level for the most recent part of the time-series but they have never been compiled.

Sampling of commercial catch: Sampling of commercial catch is conducted by the national institutes according to the EU Data Collection Framework (DCF). However, due to the small amount of annual landings, sampling of commercial catches is sparse and also several countries might be exempted to sample turbot in 3.a. Sweden has not sampled turbot in 3.a in the last decades. In the past, biological samples of turbot from the Danish fisheries in 3.a have been taken both from landed catches and through the national at-sea-sampling programme.

The DCF exemptions to the general DCF sampling rules are:

1) Concerning lengths: the national programme of a Member State can exclude the estimation of the length distribution of the landings for stocks for which TACs and quotas have been defined under the following conditions:

   1.1) the relevant quotas must correspond to less than 5% of the Community share of the TAC or to less than 100 tonnes on average during the previous three years;

   1.2) the sum of all quotas of Member States whose allocation is less than 5% must account for less than 15% of the Community share of the TAC.

If the condition set out in point (1.1) is fulfilled, but not the condition set out in point (1.2), the relevant Member States may set up a coordinated programme to achieve the implementation of the sampling scheme described above for their overall landings, or another sampling scheme, leading to the same precision.

1. Concerning ages: the national programme of a Member State can exclude the estimation of the age distribution of the landings for stocks for which TACs and quotas have been defined under the following conditions:

   1.3) the relevant quotas correspond to less than 10% of the Community share of the TAC or to less than 200 tonnes on average during the previous three years;

   1.4) the sum of all quotas of Member States whose allocation is less than 10%, accounts for less than 25% of the Community share of the TAC.

If the condition set out in point (2.1) is fulfilled, but not the condition set out in point (2.2), the relevant Member States may set up a coordinated programme as mentioned for length sampling.

If appropriate, the national programme may be adjusted until the 31st of January of every year to take into account the exchange of quotas between Member States.

Due to the relatively small numbers of turbot in commercial catches (per trip) and the high commercial value of this species, it is very difficult to collect data on biological variables in sufficient numbers for a meaningful analysis. Fishermen very often do not allow observers to take turbot otoliths on board of commercial vessels (even when informing them that it is possible to sample the otoliths through the operculum in this species, making it unnecessary to cut open the heads and thus not influencing the appearance of individual fish and their value to buyers in this way) or set aside sampling gonads for maturity staging (although the fish are gutted on board anyhow). Neither has buying turbot as part of the market sampling been considered an option for most countries either, because of the high prices. However, including the biological sampling in MS national proposals as a part of the DCF should solve this problem. On surveys, catches of turbot are generally even lower than on commercial vessels. Furthermore, turbot is a coastal, shallow water species meaning that offshore surveys such as the regular International Bottom-trawl Survey misses important habitat for turbot.

B.2. Biological

Catch-at-age data (catch numbers-at-age, mean weights-at-age in the catch, mean length-at-age) are derived from the raised national figures received from the national laboratories. The data are obtained either by market sampling or by onboard observers. However, it remains to be investigated how many samples have been collected in the past and are available at the national laboratories level, which can be compiled for stock assessment purposes. It is also important that ages have been read using the same preparation techniques (section and stained, WKART, Workshop of age reading in turbot 2008 (ICES 2008)).

Mean weights-at-age in the stock and proportions of mature individuals (maturity ogive) are derived from the IBTS and Havfisken survey (see Section B.3.2). Also, a workshop has taken place in IJmuiden in 2012 (WKMSTB, Workshop on Maturity Staging of turbot and brill (ICES 2012)). The workshop agreed on a common six point maturity scale for turbot across laboratories, and proposed optimal sampling strategy to estimate accurate maturity ogives.

Natural mortality

Natural mortality (M) at age will be estimated using biological information on growth, length–weight relationship and maximum size using the PRODBIOM software (Abella *et al*., 1997; Cardinale *et al*., 2011b). Alternatively, the same M as used in the North Sea assessment might be used, that was estimated from literature data using the equation of Gislason *et al.* (2010).

B.3. Surveys

B.3.1. International Bottom-trawl Survey

The International Bottom-trawl Survey (IBTS) started out as the International Young Herring Survey (IYHS) in 1966 (Heessen *et al*., 1997). The survey was standardized gradually from 1977, and is considered to be fully standardized from 1983 onwards, where it became known as the International Bottom-trawl Survey (IBTS). The surveys are carried out in 1st quarter (February) and in 3rd quarter (August–September) using standardized procedures among all participants. The standard gear is a GOV trawl, and at least two hauls are made in each statistical rectangle. Size information of the turbot catches is available and they can be used to construct an ALK or to estimate the proportion of the different age classes in the population for each year and season.

B.3.2. KASU Bottom-trawl Survey

The KASU survey is a standard BITS (Baltic International Trawl Survey), another group of standardized surveys. The trawl is a standard TV3-520 with rubber discs of 10 cm diameter on the groundrope and with a trawl speed at 3 knots. This trawl targets flatfish better than IBTS and is designed to provide annual abundance indices for cod, plaice and sole. This survey takes place in the Kattegat and Belt Sea twice a year in February and November, and is conducted by a Danish vessel, Havfisken from DTU Aqua. KASU time-series start in 1996 for the first quarter and 1994 for the fourth quarter data.

KASU data have been revised in 2006, due to changes in the database combined with a change of extraction programs in 2005. The revision of last year indices highlighted data treatment errors and the new time-series is considered improved compared to the old one.

Size information of the turbot catches is available from KASU and they can be used to construct an ALK or to estimate the proportion of the different age classes in the population for each year and season.

Data storage: The data are initially tabulated in an excel sheet where the data are scrutinised for consistency and quality, and the different correction factors that standardize the data among nations is applied. In the case of 3.a, only Sweden has conducted the IBTS survey so the standardization does not apply.

Index Calculation: An aggregated and standardized survey catch per unit of effort has been calculated up to 2009 by Cardinale *et al*., (2009) using IBTS survey data and historical data from Swedish trawl surveys since 1926. In the absence of age information for the surveys, statistical age slicing procedures (Scott *et al*., 2011) might be used to derive the number of fish per age class using length–frequency information from the survey.

B.4. Commercial cpue

Not used in this stock. However, data on catches and size of turbot should be available from the Danish sole fisherman survey, and also possibly from the Kattegat cod fisherman surveys (2009–2011).

B.5. Other relevant data

C. Historical stock development

C.1. Choice of stock assessment model

The turbot in 3.a has never been assessed before.

C.2. Model used as basis for advice

The choice of the assessment model will be contingent on the amount and quality of the available data.

C.3. Assessment model configuration

The choice of the assessment model configuration will be contingent on the amount and quality of the available data.

D. Short-term projection

Short-term projections are not carried out for this stock.

E. Medium-term projections

Medium-term projections are not carried out for this stock.

F. Long-term projections

Long-term projections are not carried out for this stock.

G. Biological reference points

MSY framework for North Sea herring

There is no ICES MSY framework biomass trigger point and fishing mortality for this stock.

Precautionary reference points

There are no ICES precautionary reference points for biomass and fishing mortality for this stock.

H. Other issues

H.1 Biology of the species in 3.a

Turbot lives on sandy, rocky or mixed bottoms and is one of the few marine fish species that also inhabits brackish waters. Turbot is a batch spawner and in marine waters eggs are pelagic Spawning only occurs in marine waters (pelagic eggs), where it is a batch spawner (Murua and Saborido-Rey, 2003). The spawning season generally ranges from April to August. Turbot is one of the fastest growing flatfish. During the juvenile phase growth rates are high, turbot can reach 30 cm in three years. Growth curves of males and females diverge markedly from about age three and onwards, females growing larger than males (Molander, 1964; Jones, 1974). During the first years of life females grow from 8 to 10 cm a year. Females older than ten years still grow 1 or 2 cm a year. Turbot is a typical visual feeder and adults feeds mainly on highly mobile prey like other bottom-living fishes small pelagic fish and also, to a lesser extent, on larger crustaceans and bivalves. Due to their large mouthsize compared to other flatfishes they eat macrofauna (>1 mm) from the beginning of their benthic lives. The diet of the juveniles has been shown to consist of copepods, shrimps, barnacle larvae and gastropod mollusc larvae (Jones, 1973).

Turbot is a rather sedentary species, although more long distance migratory patterns have been observed. In the North Sea, migrations from the nursery grounds in the southeastern part to the more northern areas have been recorded (ICES 2012). Nevertheless, tagging studies from three different parts of the Baltic Sea all showed that adult turbot are very stationary, have high spawning site fidelity and that 95% of the fish moved less than 30 km from tagging site, although a few individual specimens showed displacements of 100s of km (Johansen, 1916; Aneer and Westin, 1990; Florin and Franzen, 2010). Thus, turbot generally occur in spatially separated stock units as it spawns at specific localities in shallow areas during summer (Molander, 1964; Curry-Lindahl, 1985; Voigt, 2002; Iglesias *et al*., 2003; Florin and Franzén, 2010) and with restricted movements as adults (Aneer and Westin, 1990; Støttrup *et al*., 2002; Florin and Franzén, 2010), and exhibit strong spawning site fidelity (Florin and Franzén, 2010). Inspection of historical data from the Skagerrak–Kattegat area also indicates spatially separate stock structure, at least in terms of spawning components, which is persistent over time (Cardinale *et al*., 2009).

H.2. Stock dynamics, regulation and catches through 20th century

According to time-series of standardized survey cpue (Cardinale *et al*., 2009), the reduction of turbot in 3.a occurred at the beginning of the industrialized fishery, which is usually considered to be the main cause of the decline of several stocks of many demersal species stocks in 3.a (Cardinale *et al*., 2012), showing instead that the pre-industrial fishery had already had a significant impact on the stock. Historical survey data shows that biomass of turbot in 3.a has declined at about 86% since 1925 with regard to initial values; the maximum individual body size has decreased around 20 cm from the beginning of the time-series (Cardinale *et al*., 2009). Moreover, the northern stock component within Area 3.a has been eradicated. These trends are likely to be underestimated due to the conservative approach used by assuming a low level of “technical creeping” for such a long period of time, suggesting that the actual reduction in biomass might have been between 92% and 95% (Cardinale *et al*., 2009). These results indicated a depleted status of the stock in 3.a and also different stock dynamics within the area (i.e. in comparison between the Skagerrak and the Kattegat) and also when compared to the estimated trends for the North Sea (ICES 2012).

An alternative interpretation to the overexploitation hypothesis is that the quantity and quality of the turbot nursery grounds has deteriorated due to pollution (in particular due to eutrophication) and increased frequency of hypoxia events occurring in the shallow sandy coastal waters of Denmark and Sweden (Pihl *et al*., 2005), affecting the productivity of the stock. However, the decline of biomass was also accompanied by a large decrease in average maximum length, with large individuals, more abundant at the onset of the last century, being the first to be fished out with the beginning of the industrialized fishery. Thus, the above considerations corroborate the hypothesis that observed trends in length and stock size over the first part of the last century are a result of overexploitation.

H.3. Current fisheries

There is no direct or target fisheries of turbot in 3.a. The species is caught as bycatch in the trawl, trammelnet and gillnet fisheries, although due to its high economic value, targeting might occur for short period during the year in specific areas and seasons.

H.4. Management and ICES advice

Management plan

Hitherto, no management plan has been considered for turbot in 3.a.

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