Agenda Item 9  Co-operation with international organisations

Document code:  9/1
Date:  17.04.2007
Submitted by:  ICES

STATUS OF COMMERCIAL FISH SPECIES IN THE BALTIC SEA

ICES has been invited to inform the HELCOM HABITAT 79/2007 meeting regarding the status of the commercial fish species in the Baltic Sea. The enclosed document provides an extract from the latest Report of the ICES Advisory Committee on Fisheries Management, Advisory Committee on the Marine Environment and Advisory Committee on Ecosystems, 2006. (ICES Advice. Books 1-10. 8, 119 pp.)

The Meeting is requested to consider the document and to take note of the information.
ICES information: Status of commercial fish species in the Baltic Sea.

(Extract from: Report of the ICES Advisory Committee on Fisheries Management, Advisory Committee on the Marine Environment and Advisory Committee on Ecosystems, 2006. ICES Advice. Book 8, 119 pp.)

Ecosystem component(s)

Fish community

The distribution of the roughly 100 fish species inhabiting the Baltic is largely governed by salinity. Marine species (some 70 species) dominate in the Baltic Proper, while freshwater species (some 30–40 species) occur in coastal areas and in the innermost parts (Nellen and Thiel, 1996 – cited in HELCOM, 2002). Cod, herring, and sprat comprise the large majority of the fish community in biomass and numbers. Commercially important marine species are sprat, herring, cod, various flatfish, and salmon. Sea trout and eel, once abundant, are of very low population sizes. Sturgeons, once common in the Baltic Sea and its large rivers are now extinct from the area. Recruitment failures of coastal fish, e.g. perch (*Perca fluviatilis*) and pike (*Esox lucius*) in Sweden have been observed along the Swedish Baltic coast (Nilsson et al., 2004; Sandström and Karås, 2002).

Cod is the main predator on herring and sprat, and there is also some cannibalism on small cod (Köster et al., 2003a). Herring and sprat prey on cod eggs, and sprat are cannibalistic on their eggs, although there is seasonal and inter-annual variation in these effects (Köster and Möllmann, 2000a).

The trophic interactions between cod, herring and sprat may periodically exert a strong influence on the state of the fish stocks in the Baltic, depending on the abundance of cod as the main predator. To accommodate predator-prey effects, information (e. g., predation rates by cod on herring and sprat) multispecies assessments are used in the assessment of pelagic stocks.

The major environmental influences on ecosystem dynamics

Variations in the abiotic environment of the Baltic Sea are strong and depend on climate forcing. Populations of fish are affected by this variability both with respect to growth and recruitment. The growth rate of herring and sprat diminish with reduced salinity in the eastern and northern part of the Baltic (Flinkman et al., 1998; Cardinale et al., 2002; Möllmann et al., 2003a; Cardinale and Arrhenius, 2000; Rönkkonen et al., 2004). The recruitment of herring in the Gulf of Riga and sprat in the entire Baltic are positively related to spring temperatures and the North Atlantic Oscillation index (MacKenzie and Köster, 2004).

The recruitment of the eastern cod stock depends primarily on the volume of water with sufficient oxygen content and salinity available in the deeper basins (Sparholt, 1996; Jarre-Teichmann et al., 2000; Hinrichsen et al., 2002; Köster et al., 2003a; and see below). The present hydrographic situation in the central basins of the southern Baltic suggests that during the spawning season in 2005, the most favourable conditions for cod egg survival are expected still to be restricted to the Bornholm Basin and the Slupsk Furrow, and not in the more eastern basins.
The major effects of the ecosystem on fish stocks

Central Baltic cod

The spawning areas for Central Baltic cod have in the past been the Bornholm, Gdansk, and Gotland Deeps (Figure 1). The Bornholm Deep has been important in all years, while the Gdansk and Gotland Deeps have been important only in years where the salinity and oxygen conditions have allowed successful spawning, egg fertilisation, and egg development, and when the spatial distribution of the cod stock has included these areas. The volume of water suitable for cod spawning and egg survival ("reproductive volume", RV) has been very low or zero since the mid-1980s in the Gotland Deep (Figure 2) except 1994 (as a result of the 1993 inflow, MacKenzie et al., 2002). The same is true for the Gdansk Deep except that for 1995–1999 there have been several positive RV values. Prior to the mid-1980s there were many periods where the RV was high in both areas and cod reproduction took place.

The present hydrographic situation has deteriorated in the Bornholm Basin, Gdansk Deep, and Gotland Deep throughout the last year. While oxygen concentrations in the Gdansk Deep are relatively similar in February 2004 and 2005, the location of the halocline is deeper and salinity lower in 2005, narrowing down the water layer available for successful cod eggs.

In spring 2005 the hydrographic situation in the central basins of the southern Baltic suggests that cod egg survival is possible in the Bornholm Basin. However, areas with sufficient oxygen conditions for successful cod egg development are mainly restricted to the southern part of the basin. Within the central and northern part of the Bornholm Basin, it appears unlikely that cod egg survival will occur at relatively high levels.

In general, the 2005 hydrographic situation in the Bornholm Basin appears to be relatively unfavorable, which excludes a further introduction of saline, oxygenated water into the eastern basins from the Bornholm Basin in the near future. Normally major inflow situations into the Bornholm Basin occur in winter and are very seldom later than March, thus making a substantial improvement of the present conditions in the Bornholm Basin within the next months unlikely.

The Baltic Sea is characterised by a series of deep basins separated by shallow sills, and an inflow will usually fill up the first basin (the Bornholm Deep) only, with little or no transport in an eastern direction. Only under exceptional circumstances will the eastern Baltic basins benefit from the water exchange. Thus, hydrographic monitoring and the unique topography make predictions of RV in each area possible in a given year, when conducted after the inflow period in January to March. The additional effects of eutrophication on the fisheries are complex and difficult to resolve, but any process leading to a reduction in oxygen concentration in the deep layers during cod spawning periods will affect cod egg survival, as well as the survival of benthic animals that are prey for demersal fish species.

Central Baltic cod peak spawning time was in July–August during the first half of the 20th century, but changed to May until the mid-1980s when it slowly moved backwards in time year-by-year to June and July by around 1995 (Wieland et al., 2000). It is likely that for 2004 the main spawning time was June–July–August. The distribution of spawning effort, egg mortality (Wieland et al., 1994; Wieland and Jarre-Teichmann, 1997; Köster and Möllmann, 2000b), larval and early juvenile mortality and atmospheric forcing conditions post spawning (Hinrichsen et al., 2002) all contribute to uncertain recruitment predictions (Köster et al., 2001; 2003a,b). The dynamics of maturation influence the estimation of reference points, and values of SSB relative to these reference points (Köster et al., 2003b).
Clupeids

Sprat and herring are the dominant zooplankton predators in the ecosystem. However, it is not easy to differentiate the effects of changes in zooplankton predator abundance and consumption (Möllmann and Köster 2002) from the effects on zooplankton of changing nutrient availability and hydrographic conditions (Möllmann et al. 2003b).

The growth and condition of herring deteriorated along with the decline in the abundance of their main food, *Pseudocalanus* sp. (Möllmann et al., 2003a; Rönkkönen et al., 2004), and earlier than the sprat stock increased in abundance. The reason for the decrease in *Pseudocalanus* sp. have primarily been related to lower salinity and low oxygen conditions (Möllmann et al., 2003a; Schmidt et al., 2003), and subsequent increased predation by sprat may have amplified its decline (Möllmann and Köster, 2002; Möllmann et al., 2004).

For Baltic sprat a strong coupling between the NAO index, ice/temperature conditions, and recruitment has been demonstrated by MacKenzie and Köster (2004). Köster et al. (2003b) were able to improve the S/R relationship presently used in the ICES assessment by almost 50% by incorporating SSB, temperature, and growth anomalies. However, the understanding of the underlying processes is still limited (ICES, 2004a).

Depletion of cod in the Baltic has contributed to a shift in the trophic structure from a gadoid-dominated system to a clupeoid-dominated system (e.g. Köster et al. 2003). This has been accompanied by shift in zooplankton and phytoplankton, for which there is increasing evidence, and which may also be partially a consequence of eutrophication (ICES 2006, WKIAB). The change in species dominance has far-reaching consequences for people living in coastal areas, and may be very difficult to reverse through management. Methodology needs to be developed for management advice to take regime changes into account.

Salmonids

The M74 syndrome has lead to high mortality of salmon yolk-sac fry. It seems likely that M74 is linked to the diet of salmon in the Baltic and changes in the ecosystem. The incidence of M74 is statistically well correlated with parameters describing the sprat stock (Karlsson et al., 1999), but any causal connection has not been shown. The occurrence of M74 has been linked to low levels of thiamine (vitamin B1), and yolk-sac fry suffering from M74 can be restored to a healthy condition by treatment with thiamine. The mean value of M74 can be estimated to have been below 5% in 2004, and a low level is predicted for 2005.

Seals

Predation pressure by seals on fish such as herring and salmon are potentially important in the northern Baltic Sea. The impact of seal predation on the herring in SD 30 have been investigated and found to have very limited impact on stock dynamics at present (ICES 2006, ACFM: WGBFAS).

Human impacts on the ecosystem

Fishery effects on benthos and fish communities

In the Central Baltic cod and sprat spawn in the same deep basins and have partly overlapping spawning seasons. However, their reproductive success is largely out of phase. Hydrographic-climatic variability (i.e., low frequency of inflows from the North Sea, warm temperatures) and heavy fishing during the past 10–15 years have led to a shift in the fish
community from cod to clupeids (herring, sprat) by first weakening cod recruitment (Jarre-Teichmann et al., 2000) and subsequently generating favorable recruitment conditions for sprat, thus increasing clupeid predation on early life stages of cod (Köster and Möllmann, 2000a; Köster et al., 2003b; MacKenzie and Köster, 2004). The shift from a cod- to a sprat-dominated system may therefore be explained by differences in the reproductive requirements of both fish species in a changing marine environment. Additionally, the shift in dominance was supported by high fishing pressure on cod, a top-down effect which was also maintained after the severe reduction in biomass (see also Jarre-Teichmann, 1995). Possible factors leading to future destabilization of the sprat dominance include unfavourable hydrographical conditions for sprat reproduction, e.g. low water temperatures in spring following severe winter, or high fishing mortalities caused by the developing industrial fishery, with concurrent low fishing pressure on cod and inflow of oxygenated water from the North Sea.

Coastal fishery by anglers and commercial fishers has probably also influenced ecosystem structures (Hansson et al., 1997). This impact is generally more local than that of the offshore fishery, however, since most of the coastal fish species are relatively sedentary.

**Bycatch of fish**

The total bycatch of fish in the Baltic fisheries is presently unknown. The EU has supported several very recent studies of bycatch, the results of which have been compiled by ICES (2000). These studies primarily concern the major fisheries for cod, herring, and sprat, and these have low bycatches. The less important smaller fisheries can have a high proportion of bycatch (HELCOM, 2002).

It is currently impossible to come up with quantitative accounts of the bycatch of cod in the small-meshed sprat and herring fishery in the cod spawning areas (ICES, 2004b (Advice on IBSFC request on closed areas)).

The occurrence of lost nets has been surveyed in areas where gillnet fishing is practiced, and lost nets are frequent (www.fiskeriverket.se/miljofragor/pdf/okt-rapp_webb.pdf). Lost gillnets in the Baltic cod fishery are most likely of concern for cod fishing mortality since 30–50% of the landings originate from the net fishery. Experiments show that during the first 3 months, the relative catching efficiency of "lost" nets decrease by around 80%, thereafter stabilising at around 5–6% of the initial level (Tschernij and Larsson, 2003).

**Bycatch of seabirds and mammals**

Fishing nets, in particular set nets, have caused considerable mortality for long-tailed ducks (Clangula hyemalis), velvet scoters (Melanitta fusca), eiders (Somateria mollissima), and black scoters (Melanitta nigra). There are also reports of guillemot and razorbill (Alca torda) mortality in the driftnet fishery for salmon (HELCOM, 2003).

Reports suggest that fisheries bycatches amount to 0.5–0.8% of the porpoise population in the southwestern part of the Baltic Marine Area each year, as well as 1.2% of the porpoise population in the Kiel and Mecklenburg Bays and inner Danish waters (Kock and Behnke, 1996). Estimates of the harbour porpoise population are uncertain, however, and the number of porpoises bycaught in fisheries is probably underestimated. The loss of porpoises to fishery in the Baltic Marine Area may be too high to sustain the population (ICES, 1997).

Seals have been recorded caught in fyke nets, set nets, and salmon driftnets, but although the recorded data almost certainly underestimate the total number of bycaught seals, the
added mortality does not appear to restrain the seal populations from increasing (Helander and Härkönen, 1997).

Fishing activities will also affect the seabird community through the discarding of unwanted catch and fish offal. Studies indicate, for example, that over 50% of the offal discarded in the Baltic Marine Area will be consumed by seabirds (ICES, 2000).

**Other effects of human use of the ecosystem**

Human society uses the Baltic for many other purposes, including shipping, tourism, and mariculture. Overviews are given in HELCOM (2002; 2003) and Frid *et al.* (2003). Shipping may pose threats due to transport and release of hazardous substances (e.g., oil) and non-indigenous organisms. The former would likely have only relatively short-term effects (e.g., direct mortality of individuals in a restricted time and area), whereas the latter are more likely to have longer-term and more widespread effects (e.g., influences on energy flows or species interactions in food webs).

**Figure 1**

Assessments and advice

Stock trends

Analytical assessments are carried out for all cod, herring and sprat stocks and for one flounder stock. Results of the assessments are presented in the subsequent sections of the report.

Cod in Subdivisions 22-24 (Western Baltic cod). The cod stock in the Western Baltic has historically been much smaller than the neighbouring Eastern Baltic stock, from which it is biologically distinct. It appears to be a highly productive stock, which has sustained a very high level of fishing mortality for many years. Recruitment is rather variable and the stock is highly dependent upon the strength of incoming year classes. Spawner biomass has been at or below Bpa since 2002.

Cod in Subdivisions 25-32 (Eastern Baltic cod). The Eastern Baltic cod Stock is biologically distinct from the adjacent Western Baltic (Subdivisions 22-24) stock although there is some migration of fish between areas. Spawning is confined to the deep basins where egg survival depends on oxygen concentration in the deep saline water layer where fertilized eggs are neutrally buoyant. The total and spawning stock biomass increased by the end of the 1970s due to the extremely abundant year classes in 1976, 1977 and 1980 and favourable reproduction conditions in the southern and central Baltic Sea. The spawning stock declined from the historically highest level during 1982–1983 to the lowest level on record in 2004 and 2005. The decline of the stock was a result of an increase of the effort in the traditional bottom trawl fishery, introduction of gillnet fishery, and decreased egg and larval survival due to unfavourable oceanographic conditions (i.e., low oxygen concentrations for eggs and low food supply for larvae). Since the mid-1980s cod reproduction has only been successful in the southern spawning areas - Bornholm Basin and Slupsk Furrow. Although the present estimates of stock are uncertain due to misreporting of landings, discarding and age reading problems, all available information indicates that the SSB is at a very low level and the stock is considered to be below the biological reference points. Recruitment since the late 1980s has continued to be at a low level, although the year classes 2000 and 2003 may be stronger than other recent year classes.

Flounder in Subdivisions 24&25. The stock structure of the flounder in the Baltic Sea is uncertain. Stock identifications differ between studies relying on migration patterns (Aro 1989, Bagge and Steffensen 1989), spawning behaviour (Nissling et al. 2000), or microsatellite analyses (Florin and Höglund, in prep.). Migration studies indicate that there are several rather distinct flounder stocks (populations). Flounder is regularly distributed in all parts of the Baltic Sea, except in the Bothnian Bay, the most eastern part of the Gulf of Finland and the deepest areas of the Gotland Deep. According to migration studies (Aro 1989), there are at least three stocks in the south-western and south-eastern Baltic (ICES Sub-divisions 22-26), three in the central and north eastern Baltic (ICES Sub-divisions 27-28), in the Åland Sea, one in the Archipelago Sea and the southern Bothnian Sea, and two in the Gulf of Finland.

The migrations between the mature flounder stocks are quite sparse (Aro 1989). The natural boundaries of the stock in the south-western and central southern Baltic (ICES Subdivisions 24 an 25) may be drawn from the southern part of the Öland Island to the Rozewie on the Polish coast in the east and the Darßer Schwelle in the west. Spawning takes place in the Arkona Deep, the Slupsk Furrow and the Bornholm Deep at a depth of 40-80 m in the period
from the second half of February to May. After spawning feeding migrations are directed to the shallow coastal areas, southwards to the coasts of Germany (to the west up to the Island Rügen) and Poland (to the east up to the areas of Rozewie) and northwards to the south coast of Sweden. During the late autumn and early winter there is a spawning migration to the main spawning grounds, and some part of the mature stock feeding in the Arkona region migrates to the Bornholm Basin to spawn.

A preliminary genetic study (Florin and Höglund, in prep.) of flounder from 12 different places ranging from Åland in the northern Baltic Sea to the Danish west coast supports the notion of genetically differentiated flounder stocks, by showing that genetic distance is significantly correlated to geographic distance. However, the results indicate that rather than a high number of small stocks, three major different groups of flounder could be identified: (1) Skagerrakk/Kattegat (subdivisions 20-21), (2) Southwest Baltic Sea (subdivisions 22-25), and (3) Western Baltic Sea (subdivisions 26-32) (for more details, see Gårdmark and Florin, 2006).

**Herring in Sub-divisions 25-29&32 excl. Gulf of Riga (Central Baltic herring)** is the largest herring stock assessed for the Baltic and it comprises a number of spawning components. This stock complex experienced a high biomass level in the early 1970s, but has declined since then. The proportion of the various spawning components has varied in both landings and in stock. The southern components growing to a relatively large size has declined and at present the more northerly components where individuals are reaching a maximum length of only about 18-20 cm, are dominating in the landings. The recruitment has been below the long-term average since the beginning of the 1990s. The 2002 year class is relatively large and the spawning stock has increased slightly in the most recent years. The amount of reported landings is uncertain as it is mostly caught in mixed fisheries together with sprat.

**Gulf of Riga herring.** The stock is classified to have a full reproduction capacity. The spawning stock biomass of the Gulf of Riga herring has been rather stable at the level of 40,000-60,000 t in the 1970s and 1980s. The SSB started to increase in the late 1980s, reaching the record high level of 120,000 t in 1994. Since then the SSB has been in the range of 85,000-120,000 t. The year-class abundance of this stock is significantly influenced by hydro-meteorological conditions (by the severity of winter, in particular). Mild winters in the second half of 1990s have supported the formation of series of rich year-classes and increase of SSB. Due to low and only occasional presence of sprat in the Gulf, there is no mixed pelagic fishery in the Gulf of Riga.

**Herring in Subdivision 30.** The spawning stock of Bothnian Sea herring was at a relatively low level of 100 000 – 150 000 t until the mid-1980s, after which the SSB more than tripled by 1994. In 1995–2001, the SSB declined from the highest value of 410,000 t in 1994. Since 2001, the SSB has been increasing, and it was 380,000 t in 2005. Although recruitment has been on average much higher during the high biomass period, favourable environmental conditions (i.e. warm summers in late-1980s, 1997, 2001 and 2002) have contributed to the production of the large year classes. The 2002 year class is estimated to be more than twice the size of the second largest year class in the time series.

**Herring in Subdivision 31** is one of the smallest stocks assessed in the Baltic. The dynamics of the stock appears to be largely influenced by the environmental factors. The spawning stock biomass of the Bothnian Bay herring fluctuated between 26 000 t and 39 000 t during the 1980s. The SSB declined to a very low level in the late 1990s, but since year 2000 the SSB has doubled due to several good year classes in recent years, being more than 21 000 t in 2005.
Sprat in Subdivisions 22-32 is the largest stock assessed in the Baltic and is considered to be exploited sustainably and to have full reproductive capacity. The spawning stock biomass has been low in the first half of the 1980s. In the beginning of the 1990s the stock started to increase rapidly and in 1996-1997 it reached the maximum observed spawning stock biomass of 1.8 million tonnes. The stock size increased due to the combination of strong recruitments and declining natural mortality (effect of low cod biomass). In the following years a decreasing trend in stock size was observed as the result of a rather high fishing mortality (0.35-0.4). In 2005-2006 the stock is predicted to increase again due to strong year classes of 2002 and 2003. The year class 2004 is assessed as weak, and the 2005 is estimated above the average. The main part of the sprat catches is taken in mixed sprat-herring fishery, and the species composition of these catches is very imprecise in some fishing areas /periods.

Mixed fisheries and fisheries interactions

Officially reported fish catches in the Baltic until 2004 are given in Tables 8.3.1–8.3.5. These are the catches officially reported to ICES by national statistical offices for publication in the ICES Fishery Statistics. For use in the assessments, ICES estimate discards and landings which are not officially reported, and the composition of bycatches. These amounts are included in the estimates of total catch for each stock and are presented separately for each stock in the stock summaries in Section 8.4. These estimates vary considerably between different stocks and fisheries, being negligible in some cases and constituting important parts of the total removals from other stocks. Furthermore, the catches used in assessments are divided into subdivisions, whereas the officially reported catches by some countries are reported by the larger Divisions IIIb, c, and d. The trends in Table 8.3.1 may, therefore, not correspond to those on which assessments have been based, and are presented for information only, without any comment from ICES.

Baltic cod is taken in a targeted fishery with minimal bycatches. Herring and sprat are taken in pelagic trawl fisheries, which include fisheries taking both species simultaneously. The actual composition of pelagic catches is poorly known for some fisheries because landings in some landings statistics are assigned to species according to the target species. In Denmark trawlers using mesh sizes below 32 mm fish for industrial purposes, and the species composition is determined by logbooks/sale-slips and corroborated by samples. The landings not sampled are allocated to species according to a “dominant species” rule. When using meshes larger than 31 mm trawlers are assumed to fish for human consumption and species composition is based on logbooks. The landings are allocated to fishing area according to information in logbooks. In Estonia species compositions are based on logbooks and landing declarations. Some (mostly visual) estimation by the Environmental Inspection is carried out. In Finland species compositions are by catch notifications and logbooks. Some inspections are made in harbours by regional Employment and Economic Development Centres. In Germany landings of herring from gillnets and trapnets with negligible amounts of sprat dominated the pelagic fishery till 2001. Thereafter a substantial increase in trawling pelagic fish has occurred. Species composition is determined by logbooks. In Latvia and Lithuania species composition is based on logbooks. In Poland species composition is based on logbooks and landing declarations. In Russia species composition is based on logbooks and sporadically checked by fishery inspectors in harbours. In Sweden species composition is based on logbooks. The samples taken by the Coast Guard for control purposes have so far not been used for the officially reported landings.

Overall, estimates of pelagic catch compositions are mainly based on logbooks and landing declarations, with limited supplementary sampling of catches. This means that the actual
composition is uncertain. A comparison between the composition of pelagic landings and acoustic survey data indicates large discrepancies in the proportion of herring. This could mean that commercial fleets are fishing more discriminatory than the research vessels, or that the reported proportions do not reflect the species composition particularly well.