APPLICATION OF BALTIC HERING AND COD STOCK IDENTIFICATION RESULTS TO FISHERY MANAGEMENT

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ABSTRACT

The Baltic fisheries management is facing a period of difficult change in order to adjust the Baltic herring and cod stock management units to the stock assessment units recommended by ICES. Implementation of the Baltic herring and cod stock identification results require a new management system to be evolved based on management units that correspond as closely as possible with stock assessment units. However, any revised allocation agreed among the countries would include in an individual year winner and loser countries compared to the existing allocation scheme. Implementation of new revised management system implied development of new quota allocation criteria. The "strong equity" (i.e. all players get the same share under the new as under the old sharing system), an average sharing and min-max solution are considered. This paper discusses problems associated with re-allocation of fishing possibilities among counties when redefining TAC areas. This is exemplified by the case of the Baltic herring and cod. The possibilities for a pay-off between herring and cod when seeking an optimal solution to the combined cod-herring allocation problem are discussed.

KEY WORDS: Baltic herring, Baltic cod, quota re-allocation, value-based quota allocation

INTRODUCTION

Herring in the Baltic Sea form a number of populations with different biological characteristics and not clear-cut boundaries between those populations. The history of the establishing the Baltic herring different stock and management units is reflected in the literature [Anon. 2001]. Kornilovs (2004) is comparing the two opposing opinions on Baltic herring stock structure. According to the first opinion (Ojaveer, 1988; Ojaver and Elken, 1997; Ojaveer, 2002; Ojaveer *et al.* 2004) several distinct herring populations have evolved as an adaptation to the diverse environmental conditions of the Baltic. The second opinion (Parmanne, 1990; Sparholt, 1994; Parmanne et al. 1994) is based on suggestion that differences in morphological, meristic and biological characters are more likely to be phenotypic reflection of the environmental gradient from south to north.

The spawning of spring spawning herring starts in the southern Baltic normally in March-April and in the northern areas in May-June (spring spawning herring has dominated all areas of the Baltic since the late 1960s). After spawning most of these herring migrate sometimes over long distances between spawning sites and feeding areas [Aro, 1989]. As a result of feeding migrations there is a mixture of herring of different populations in the Central Baltic during the feeding period and also in winter. Similar feeding migrations exist for herring of Bothnian Sea and Bothnian Bay and the spring spawners of the western Baltic.

According to E. Aro (2000) there are two cod stocks in the Baltic Sea: the eastern cod (distributed from the east of the Bornholm Island and up to the northern parts of the Bothnian Sea and to the Gulf of Finland), and the western cod (distributed west of the Bornholm Island). The geographical dispersal of these mixing stocks is related to the abundance of both of them. The cod spawning areas are located in the southern and central parts of the Baltic Proper, and the cod migrates to the spawning areas in the winter and early spring (Aro, 2000).

The paper of Nissling and Westin (1997) could be referred to as an example of the modern approach to the Baltic cod stock identification. Study was conducted in order to elucidate if differences in salinity requirements for successful spawning exist between the eastern Baltic cod and the western Belt Sea cod, and if adaptation to ambient salinity is possible. The results of the study suggest that stock interactions may be possible in the western Baltic spawning areas where salinity requirements for both stocks are fulfilled, but not in the eastern spawning areas as low salinity prevents successful spawning of Belt Sea cod.

There is a number of approaches for the Baltic herring and cod stock identification, each of which has certain advantages. At the same time there is no generally accepted and reliable methods for herring and cod stock identification. Herring and cod otoliths are most usually used for the routine stock identification but the results are not sufficiently reliable. Therefore the optimal solution seems to be in seeking a reasonable compromise between biological knowledge and the practical constraints set by the availability of data [Aps, 2004].

This paper discusses problems associated with re-allocation of fishing possibilities among counties when redefining the Total Allowable Catch (TAC) areas - in the language of the EU Common Fisheries Policy: relative stability. Such re-allocations might be based on biological information on stock identity that causes a redefinition of the management units also called TAC areas. Examples include (Figure 1):

1. Western and Central Baltic herring: In 2004 these are managed as one management unit with subdivisions 22-29S + 32, IBSFC has decided to split this into:

- Western Baltic subdivisions 22-24
- Central Baltic herring (excl. Gulf of Riga), subdivisions 25-29+32
- Gulf of Riga herring

2. Baltic Cod (In 2004 this is managed under one single TAC (subdivisions 22-32), however IBSFC has decided that this will become two TAC units (Subdivisions 22-24 and subdivisions 25-32)

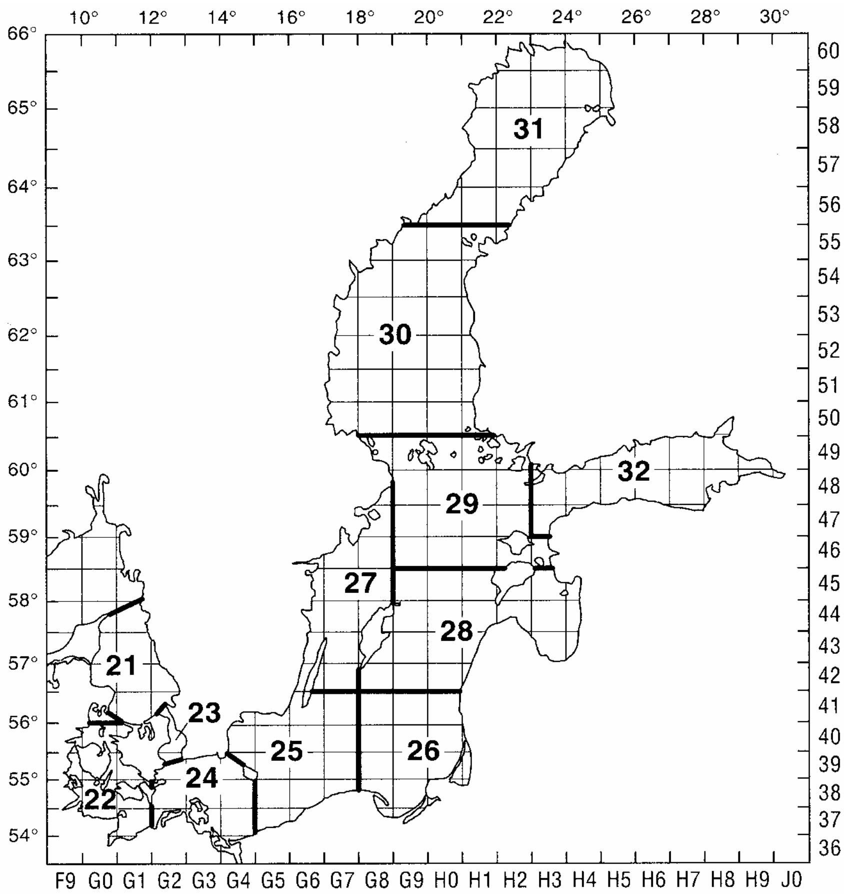

Figure 1. Baltic Sea ICES Subdivisions in IBSFC Convention Area for fisheries assessment and fisheries statistics purposes.

For any new allocation scheme to be acceptable to all countries exploiting the resource, each country should maintain the TAC share it would be entitled to under the existing allocation scheme irrespectively of the area split and independently of how the TACs might be composed. However, there may be TAC areas to which access is of little interest for a country or where political or geographical conditions deny such access. A share in a TAC may be of little value to the country unless that share can be fished or traded or swapped with another resource that is accessible.

Aps *et al.* (in press) discuss criteria under which such a reallocation can be calculated and they investigate the possibility for "strong equity", i.e. all players get the same share under the new as under the old sharing system, for an average sharing and for min-max solution to the problem. It was concluded that because access to certain areas is restricted and because some countries do not have fishing interests in certain areas, then strong equity is not possible unless a swap system involving several species are introduced. The Baltic herring problem was investigated in isolation and by means of an example it was showed where the difficulties are and what is the size of the problem in the Baltic Sea.

The paper expand the analysis presented by Aps *et al*. (in press) by considering two species for which the management unit system is changed at the same time. This is exemplified using Baltic herring and cod. The paper introduces the possibility for a pay-off between herring and cod thus seeking an optimal solution to the combined cod-herring allocation problem. In doing so individual values (prices €/kg) are associated to cod and herring respectively.

1 ANALYTICAL APPROACH

1.1. Symbols used

The symbols used in this paper are as follows:

1) TAC : total allowable quota
2) $\bar{k}$: allocation keys (fraction of total TAC) among the countries; $\bar{k}$ is a column vector ($n_c \times 1$), countries = 1,2,…, n_c. $\bar{k}^T = \{k_1, k_2, ..., k_{n_c}\}$ with $0 \le k_i \le 1$ for every i and $\sum_{c \in country} k_c = 1$.
3) tac_c : The allocated quota to country c $\overline{tac}^T = \{tac_1, tac_2, ..., tac_{n_c}\}$.
4) t_a : quota for area a, a= 1,...,n_a with $\bar{t}^T = \{t_1, t_2, ...t_{n_a}\}$
5) $\underline{\underline{n}} = \{n_{c,a}\}$ $c = 1,..,n_c$ and $a = 1,...,n_a$: Allocation to each country from each quota area $0 \le n_{c,a} \le 1$ for $\forall c, a$ and with $\sum_{c \in country} n_{c,a} = 1$ for each a
6) $\bar{\varepsilon}^T = \{\varepsilon_1, \varepsilon_2, ..., \varepsilon_{n_c}\}$: Difference between total allocation to a country under the old and new scheme
7) $E[\bar{\varepsilon}]$: Average value of $\bar{\varepsilon}$
8) λ : upper limit on the absolute difference between the quota to any country under the old and the new allocation scheme

1.2. Theory

Aps *et al* (2004) presented the theory for splitting a single TAC into several. The main elements of that theory are described below.

Let TAC be the total quota and $\bar{k}$ be the existing allocation keys (fraction of total TAC) among the countries; $\bar{k}$ is a matrix ($n_c \times 1$), countries = 1,2,…, n_c. $\bar{k}^T = \{k_1, k_2, ..., k_{n_c}\}$ with $0 \le k_i \le 1$ for every i and $\sum_{c \in country} k_c = 1$.

The allocated tac_c to country c is then $tac_c = k_c * TAC$, $c = 1,2,...,n_c$, or in matrix notation $\overline{tac} = TAC * \bar{k}$, with $\sum_{c \in country} tac_c = TAC$, because $\sum_{c \in country} k_c = 1$.

The management scheme is changed so that individual area quotas t_a in the future are set for each area a= 1,...,n_a Defining new allocation keys can be formulated mathematically.

Let the column vector $\bar{t}^{T} = \{t_1, t_2, ... t_{n_a}\}$ be the individual TACs by area and the overall $TAC = \sum_{a \in area} t_a$.

The allocation to each country from each quota area is defined by a matrix $\underline{\underline{n}} = \{n_{c,a}\}$ $c = 1,.., n_c$ and $a = 1,..., n_a$ with $0 \le n_{c,a} \le 1$ for $\forall c, a$ and with $\sum_{c \in country} n_{c,a} = 1$ for each a .

The new allocation shall conform to some form of equity compared with the old allocation. Each country will want to maintain its old allocation in terms of fishing possibilities, i.e.

$$TAC * \bar{k} = \underline{\underline{n}} * \bar{t}$$

with

$$TAC = \sum_{a \in area} t_a$$

It is therefore of interest to study the possible solutions to

$$TAC * \bar{k} = \underline{\underline{n}} * \bar{t} + \bar{\varepsilon}$$

for different conditions imposed on $\bar{\varepsilon}$. For this analysis to be realistic it must be include restrictions on $\underline{\underline{n}}$ that follows from restrictions on access by different countries to different geographical fishing areas.

Three different conditions defined below are investigated.

1. Strong equity $\bar{\varepsilon} = \bar{0}$. With unrestricted access for all countries to all areas there is only one solution to this problem that is general for all possible area quotas $\underline{\underline{n}} = \{\bar{k}, \bar{k}, ..., \bar{k}\}, j = 1,..., a$ as can be seen by considering the situation where there is only a positive quota in a single area and quotas in all other areas are zero. For a specific set of quotas $\bar{t}$ there are infinite many solutions $\underline{\underline{n}}$.

2. Mean equity $E[\bar{\varepsilon}] = \bar{0}$. The solution is

$$TAC * \bar{k} = \underline{\underline{n}} * E[\bar{t}]$$

with $TAC = \sum_{a \in country} t_a$

This equation has infinite many solutions for $\underline{\underline{n}}$.

3. Upper Bound Equity $Max[|\varepsilon_c|] < \lambda$ *or in relative terms* $|\varepsilon_c| < \lambda * tac_c$ *for* $\forall c \in country$. In this case the deviation between the allocation to each country under the old and the new allocation scheme is kept within certain bounds. There is a lower bound on λ below which there is no solution whatsoever. There is no simple solution, for a choice of λ there will be either infinite many solution or none at all.

In investigating the mean or the upper boundary equity and deviation from strong equity the mean is taken over the observed set of catches by area (depends on the species and stock). These catches are assumed to represent possible combinations of area TACs to be experienced in the future. This simulation approach is based on the practice that past catch performance is often a dominating concern when agreeing allocation keys among countries.

2. RE-ALLOCATION OF HERRING AND COD FISHING POSSIBILITIES

The revised allocation is to split one TAC into several new TACs. This split is subject to restrictions in access rights. For the purpose of this paper these access restrictions are defined based on historic fishing rights.

In the following the approach based on the example of Baltic cod and herring is discussed. The cod TAC is split into two TAC areas (Subdivisions 22-24 and subdivisions 25-32) while the herring TAC is split into three TAC areas (Subdivisions 22-24, subdivisions 25-29 (excl. Gulf of Riga) and the Gulf of Riga (part of Subdivision 28).

IBSFC also manages herring in Subdivision 30 (Bothnian Sea) and in Subdivision 31 (Gulf of Bothnia). Management of these herring is not affected by the changes and hence not included in the following considerations.

The approach taken in this analysis is:

- Find an “new” allocation scheme that is “best” in some way for cod and herring separately respecting limitations in access to certain areas;
- Apply this allocation scheme to the catches as officially report for the period 1992-2003;
- Compare the IBSFC existing allocation scheme to the new on a by year and country basis. Find the average gain/loss for each country and the variation of these gain/losses on a country by country basis;
- Introduce a value (price) €/kg for herring and cod; use this value to find the “best” allocation scheme that distribute the total value of cod and herring combined;
- Apply this allocation scheme to the combined value for each country and year 1992-2003

IBSFC allocation scheme

The International Baltic Sea Fisheries Commission (IBSFC) had established the following allocation scheme (Table 1). Formally, the ratio of annual national allocations of the agreed TAC among Fishery Zones by the IBSFC cannot be taken as reflecting any generally applicable concept, nor may it be used as a basis for TAC allocation in future. In practice, however, in order to avoid unnecessary debate, relative stability over time has been an important instrument for the IBSFC in seeking a solution on the sharing of common fishery resources. However, as it is not a formal IBSFC principle, the relative stability in national allocation proportions is based less on the TACs than on political compromise [Aps, 2004].

Table 1. IBSFC allocation scheme for the Baltic herring and cod

Country	Herring (%) Subdivisions 22-29S+32	Cod (%) Subdivisions 22-32
Estonia	10.14	1.78
EU-15	54.95	60.90
Latvia	6.86	6.77
Lithuania	2.14	4.45
Poland	20.14	21.10
Russia	5.77	5.00
Total	100	100

The list of the countries could be expanded by considering the individual sharing within EU-15 (i.e. Denmark, Finland, Germany and Sweden). However, this sharing includes additional complications involving arrangements related to the European Economic Areas agreement and the Finnish and Swedish EU Accession Treaty.

Historical fishing rights and value of the Baltic herring and cod

Historic fishing rights are based on past catch performance. For the purpose of this paper we apply the official statistics as given in the 2004 Report of the Baltic Fisheries Assessment Working Group (Anon. 2004). We exclude data that are related to estimates of unallocated (i.e. non-reported) catches and also the Faeroe Islands catches from the mid 1990s are ignored. As data before 1991 are given for the Soviet Union only and are not available split by the then soviet states data before 1991 are ignored. Data for 1991 are not entirely properly sorted and we decided to ignore data for 1991. From 1991 onwards data landed by the fleet in the former GDR are included in the German catch data. The data are presented in Tables 2-4 (herring) and in Tables 5-6 (cod).

The revised scheme for herring split the herring quota in three TAC units: subdivisions 22-24, subdivisions 25-29S + 32 and the Gulf of Riga. Based on historical rights Denmark, Germany, Poland and Sweden have TAC rights in Western Baltic (subdivisions 22-24), all countries have rights in the Central Baltic (subdivisions 25-29S and 32) while only Estonia and Latvia have TAC rights in the Gulf of Riga.

If the strong equity would be implemented on this revised allocation scheme then this means that e.g. Estonia would have both a cod and a herring quota in the Western (Subdivisions 22-24) Baltic. Also, it means that EU-15 (with membership as of September 2003) would have a herring quota in the Gulf of Riga. It may be of little interest to Estonia to have a herring quota in the Western Baltic if Estonia has no fleet to fish this quota. Vice-versa EU may not be interested in a herring quota in the Gulf of Riga as it would have no fleet that has experience in this fishing nor might Latvia and Estonia be interested in allowing other countries fishing rights in the Gulf of Riga. Accepting these restrictions of access we defined a set of access rights based on the past performance of the national fishing fleets. This access scheme is presented in Table 7.

Table 2. Herring catches ('000 tons) as used by the ICES Baltic Fisheries Assessment working group (WGBFAS) for the stock area 22-24 by country for the period 1992-2003

Year	Denmark	Germany	Poland	Sweden	Total
1992	29,8	15,6	15,5	22,5	113,4
1993	41,3	11,1	11,8	16,5	113
1994	41	11,4	6,3	7,5	104,4
1995	37,7	13,4	7,3	16,1	105,9
1996	35,1	7,3	6	9,1	89
1997	32,7	12,8	6,9	14,6	90,7
1998	30,5	9	6,5	4,5	75,3
1999	33	9,8	5,3	2,7	68,7
2000	33,5	9,3	6,6	4,9	77,6
2001	28,9	11,4	9,3	14,1	89,8
2002	17,64	22,4	0	10,72	76,46
2003	8,458	18,78	4,398	9,622	55,95

Table 3. Herring catches ('000 tons) as used by the ICES Baltic Fisheries Assessment working group (WGBFAS) for the stock area 25-29S and 32 by country for the period 1992-2003

Year	Denmark	Estonia	Finland	Germany	Latvia	Lithuania	Poland	Russia	Sweden	Total
1992	8,1	22,3	30	0	12,5	4,6	39,2	29,5	43	159,2
1993	8,9	25,4	32,3	0	9,6	3	41,1	21,6	66,4	176
1994	11,3	26,3	38,2	3,7	9,8	4,9	46,1	16,7	61,6	180,4
1995	11,4	30,7	31,4	0	9,3	3,6	38,7	17	47,2	157,9
1996	12,1	35,9	31,5	0	11,6	4,2	30,7	14,6	25,9	135
1997	9,4	42,6	23,7	0	10,1	3,3	26,2	12,5	44,1	148,2
1998	13,9	34	24,8	0	10	2,4	19,3	10,5	71	161,1
1999	6,2	35,4	17,9	0	8,3	1,3	18,1	12,7	48,9	130,9
2000	15,8	30,1	23,3	0	6,7	1,1	23,1	14,8	60,2	151,8
2001	15,8	27,4	26,1	0	5,2	1,6	28,4	15,8	29,8	124
2002	4,6	21	25,7	0,3	3,9	1,5	28,5	14,2	29,4	103,4
2003	5,3	13,3	14,7	0,2	3,1	2,1	26,3	13,4	31,8	95,5

Table 4. Herring catches ('000 tons) as used by the ICES Baltic Fisheries Assessment working group (WGBFAS) for the Gulf of Riga by country for the period 1992-2003

Year	**Estonia**	**Latvia**	**Total**
1992	9,742	14,2	24
1993	9,537	13,6	23,1
1994	9,636	14,1	23,7
1995	16,01	17	33
1996	11,79	17,4	29,2
1997	15,82	21,1	36,9
1998	11,31	16,1	27,4
1999	10,25	20,5	30,8
2000	12,51	21,6	34,1
2001	14,31	22,8	37,1
2002	16,96	22,4	39,4
2003	19,65	21,8	41,4

Table 5. Cod catches (tons) as used by the ICES Baltic Fisheries Assessment working group (WGBFAS) for the stock area 22-24 by country for the period 1992-2003

Year	Denmark	Estonia	Finland	Germany	Latvia	Poland	Sweden	Unallocated	Total
1992	12,395	0	0	3,656	0	0	1,945	0	17,996
1993	9,667	0	0	4,084	0	0	1,949	5,528	15,7
1994	14,904	0	0	4,023	0	0	4,266	7,502	23,193
1995	21,309	0	132	9,196	15	0	3,243	0	33,895
1996	30,945	50	50	12,018	32	0	5,45	2,3	48,545
1997	30,773	6	11	9,269	0	263	3,302	0	43,624
1998	21,659	8	13	9,722	13	623	2,178	0	34,216
1999	25,913	10	116	13,224	25	660	2,207	0	42,155
2000	22,327	5	171	11,572	84	926	3,262	0	38,347
2001	19,57	40	191	10,579	46	646	3,172	0	34,244
2002	13,712	0	191	7,322	71	782	2,081	0	24,158
2003	14,648	0	59	6,775	124	568	2,45	0	24,624

Table 6. Cod catches (tons) as used by the ICES Baltic Fisheries Assessment working group (WGBFAS) for the stock area 25-32 by country for the period 1992-2003

Year	Denmark	Estonia	Finland	Germany	Latvia	Lithuania	Poland	Russia	Sweden	Un-allocated	Faroe Islansa	Toyal
1992	30,42	1,368	485	6,449	1,25	1,266	13,31	1,793	15,94	0	593	72,285
1993	17,667	70	225	5,126	1,333	605	8,909	892	12,05	18,978	558	46,875
1994	24,805	952	594	7,079	2,831	1,887	14,34	1,257	25,53	44	779	79,27
1995	38,204	1,049	1,861	14,692	6,653	4,513	25	1,612	27,97	18,993	777	121,55
1996	48,494	1,388	3,139	19,358	8,741	5,524	34,86	3,306	36,12	10,815	706	160,92
1997	40,549	1,42	1,547	14,484	6,187	4,601	31,66	2,803	28,37	0	600	131,62
1998	29,477	1,196	1,039	10,992	7,778	4,176	25,78	4,599	16,61	0	0	101,64
1999	38,083	1,062	1,572	15,439	6,914	4,371	26,58	5,202	15,93	0	0	115,15
2000	32,042	609	1,819	13,08	6,28	5,165	22,12	4,231	19,17	23,118	0	104,52
2001	29,15	805	1,717	12,738	6,298	3,137	21,99	5,032	21,03	23,677	0	101,9
2002	21,543	37	1,717	8,767	4,867	3,137	15,89	3,793	14,59	17,562	0	74,336
2003	22,303	591	1,151	8,129	3,617	2,767	15,94	3,707	13,75	0	0	71,953

Table 7. Access rights used in the calculations as based on historical rights defined in Tables 2-6 (A: access, N/A: No access)

Country	Cod		Herring Subdivisions 22-29S+32		
	Subdivisions 22-24	Subdivisions 25-32	Subdivisions 22-24	Subdivisions 25-29 (excl. Gulf of Riga)	Gulf of Riga (part of Subdivision 28)
Estonia	N/A	A	N/A	A	A
EU-15	A	A	A	A	N/A
Latvia	N/A	A	N/A	A	A
Lithuania	N/A	A	N/A	A	N/A
Poland	A	A	A	A	N/A
Russia	N/A	A	N/A	A	N/A

"Best" allocation scheme

Having realised that "strong equity" is not possible we seek a definition of "best" allocation scheme. Here we choose the scheme that in a least square sense will minimise the deviation from strong equity:

$$Min = \sum_{year}\sum_{country}\left(old\ \ allocation - new\,allocation\right)^2$$

$$year = 1992, 1993, ..., 2003$$

$$country = Estonia, EU-15, Latvia, Lithuania, Poland, Russia$$

Choosing this particular criterion means that we penalise large deviations harder that small. There is an obvious problem as one of the IBSFC Contracting Parties is much larger than the others (EU-15).

The estimation is done by minimising the sum-of-squares for the 12 years 1992-2003 and the IBSFC Contracting Parties: Estonia, EU-15, Latvia, Lithuania, Poland and Russia and using the access scheme defined in Table 7. Relative value of cod and herring was estimated from the average price of landed cod (cod fresh, gutted) and fresh herring landed for human consumption. The price used were those obtained during the first quarter at Bornholm (Denmark) 2003: herring 133.333 €/tons and cod 1,466.67 €/tons.

The solution is presented in Table 8. Tables 9-11 present the differences between the old and the "best" allocation scheme measured in value (€).

Table 8. Estimated "best" allocation scheme (%) for cod and herring combined based on the total value of the combined cod and herring landings.

Cod		Allocation scheme		**Herring**		Allocation scheme	
	TAC Area	Individual	Combined		TAC Area	Individual	Combined
Estonia	25-32	2.35	1.76	Estonia	25-29S + 32	8.28	12.43
EU	22-24	69.90	72.38		G. Riga	42.05	39.12
	25-32	58.00	57.83	EU	22-24	71.95	76.10
Latvia	25-32	8.95	8.82		25-29S + 32	58.52	53.38
Lithuania	25-32	5.88	5.84	Latvia	25-29S + 32	0.00	0.00
Poland	22-24	30.10	27.62		G. Riga	57.95	60.88
	25-32	18.21	19.11	Lithuania	25-29S + 32	3.36	3.59
Russia	25-32	6.61	6.63	Poland	22-24	28.05	23.90
					25-29S + 32	20.89	21.84
				Russia	25-29S + 32	8.94	8.77
Total	22-24	100	100		22-24	100	100
	25-32	100	100		25-29S + 32	100	100
					G. Riga	100	100

Table 9. Individual Cod allocation. Value differences (€) between the old allocation scheme and the "best" allocation scheme estimated, see Table 8. A negative value means that the new allocation scheme gives that Contracting Party an advantage.

Old – new (€)	Estonia	EU-15	Latvia	Lithuania	Poland	Russia	Sum
1992	-137,180	693,729	-521,685	-342,909	693,334	-385,290	0
1993	16,253	-82,251	61,858	40,660	-82,206	45,686	0
1994	-60,158	304,178	-228,737	-150,351	304,002	-168,933	0
1995	-135,801	686,704	-516,397	-339,433	686,310	-381,385	0
1996	-83,971	424,533	-319,238	-209,837	424,285	-235,772	0
1997	33,597	-170,054	127,894	84,068	-169,964	94,459	0
1998	39,735	-201,068	151,214	99,396	-200,959	111,681	0
1999	133,583	-675,725	508,163	334,022	-675,349	375,307	0
2000	123,448	-624,458	469,608	308,680	-624,110	346,832	0
2001	38,359	-194,105	145,978	95,954	-194,000	107,814	0
2002	6,466	-32,777	24,655	16,207	-32,762	18,210	0
2003	38,647	-195,532	147,049	96,657	-195,425	108,604	0
Average	-53,714	271,562	-204,208	-134,227	271,403	-150,817	0

Table 10. Individual Herring allocation. Value differences (€) between the old allocation scheme and the “best” allocation scheme estimated, see Table 8. A negative value means that the new allocation scheme gives that Contracting Party an advantage

Old - new (€)	Estonia	EU-15	Latvia	Lithuania	Poland	Russia	Sum
1992	577,058	-1,037,248	862,321	-2,362	-426,359	26,592	0
1993	624,227	-1,129,619	1,070,563	-43,665	-440,062	-81,444	0
1994	428,371	-806,324	991,620	-100,144	-281,591	-231,931	0
1995	70,685	-170,829	163,490	-2,017	-88,867	27,539	0
1996	-50,758	39,318	63,327	-24,382	9,232	-36,736	0
1997	-240,220	368,604	-330,656	16,128	112,712	73,432	0
1998	-24,515	-19,781	293,357	-80,889	17,542	-185,713	0
1999	-253,506	393,163	-269,243	-10,042	140,782	-1,154	0
2000	-284,981	436,375	-227,035	-33,311	168,261	-59,310	0
2001	-345,237	558,283	-570,523	42,707	173,473	141,297	0
2002	-670,832	1,121,500	-1,038,820	46,643	393,257	148,251	0
2003	-932,219	1,575,208	-1,436,465	56,139	566,775	170,563	0
Average	-45,499	30,308	42,252	-15,329	-386	-11,347	0

Table 11. Value differences (€) between the old allocation scheme and the “best” combined allocation scheme estimated, see Table 8. A negative value means that the new allocation scheme gives that Contracting Party an advantage

Old – new (€)	Estonia	EU-15	Latvia	Lithuania	Poland	Russia	Sum
1992	112,239	24,996	379,834	-360,530	185,124	-341,663	0
1993	-15,281	-678,988	1,128,278	-38,717	-389,454	-5,838	0
1994	-62,555	-7,651	815,930	-270,581	-95,412	-379,732	0
1995	67,322	483,149	-258,684	-328,252	390,071	-353,606	0
1996	448,286	-62,371	-74,206	-191,378	170,404	-290,735	0
1997	124,147	-239,383	-105,319	124,466	-64,767	160,855	0
1998	-27,181	-206,744	524,058	21,219	-243,607	-67,746	0
1999	172,119	-778,188	330,250	345,692	-437,522	367,649	0
2000	-93,289	-411,617	301,151	283,001	-369,691	290,446	0
2001	-111,659	59,390	-382,310	152,315	34,845	247,419	0
2002	-581,922	1,007,025	-1,031,619	66,901	370,067	169,547	0
2003	-719,385	1,197,839	-1,319,160	161,170	400,637	278,899	0
Average	-54,026	288,666	-96,173	-142,811	163,187	-158,843	0

Comparison of the value differences between the old allocation scheme and the “best” individual or combined allocation schemes for the Baltic herring and cod is revealing just the same pattern – any revised allocation agreed among the countries would include in an individual year winner and loser countries compared to the existing allocation scheme.

The results can also be compared on the value maximum gain/loss between the old allocation scheme and the “best” individual or combined allocation schemes (Table 12). The value maximum gain/loss extremes are remarkably symmetrical and largely depends on the different dynamics of the herring and cod stocks.

Table 12. The value maximum gain/loss between the old allocation scheme and the "best" individual or combined allocation schemes

Old-new ('000 €)	Individual Cod	Individual Herring	Combined Cod + Herring
Loss	694	1,575	1,198
Gain	-676	-1,436	-1,319

Figure 2 shows the differences from strong equity experienced with the combined allocation scheme for the period 1992-2003 measured in '000 €. The influence of the favourable herring stock in the Gulf of Riga in the years 2000 and later is clearly seen. Positive result means that the country get more fishing possibilities measured in value from the old allocation scheme compared to the new allocation scheme, therefore a negative result means that the country will see itself as a "winner".

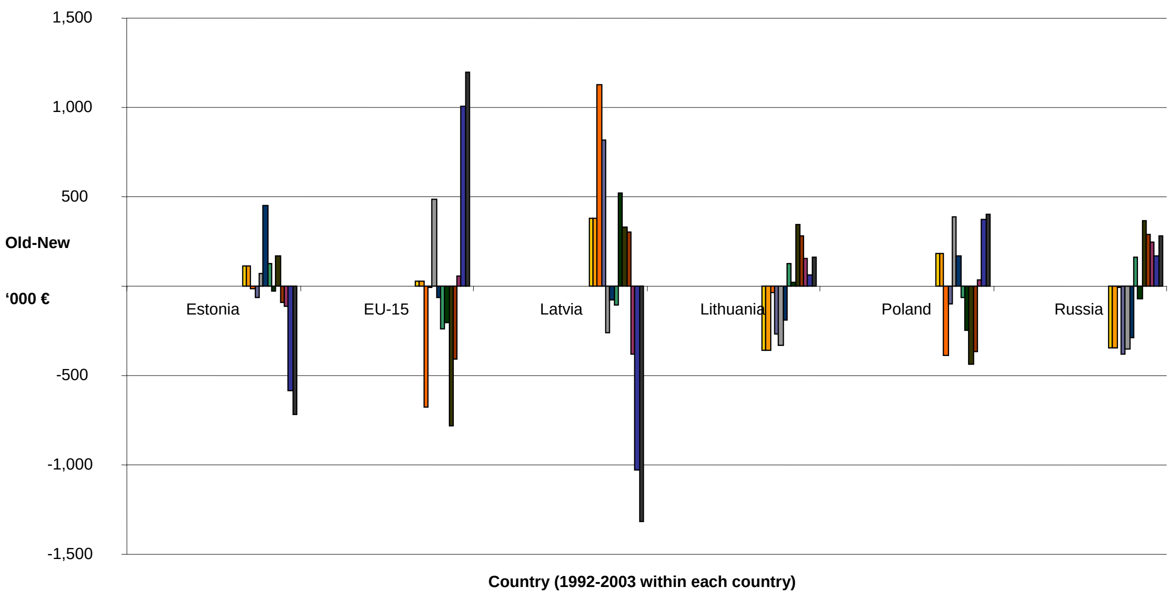

Figure 2. Value ddifferences (€) for combined allocation scheme by country and by year

The Common Fisheries Policy introduced in the early 1980ss the concept of "cod equivalent" promoting the idea that it is the total value of the landed fish that is allocated among fishing countries rather than individual species quotas. The same notion is seen in international negotiations where "quota swop" are agreed involving swops between quotas of different species and of species that have different value. The BEAM 4 and BEAM 5 systems developed through FAO include the same idea (Sparre and Willmann, 1993).

CONCLUSIONS

There is no generally accepted and reliable methods for herring and cod stock identification available. Therefore, the optimal solution in application of the stock identification results to the fishery management seems to be in seeking a reasonable compromise between biological knowledge and the practical constraints set by the availability of data.

Practical implementation of the Baltic herring and cod stock identification results to fishery management imply the re-allocation of future fishing possibilities. This is painful and lengthy process because of any revised allocation agreed among the countries would include in an individual year winner and loser countries compared to the existing allocation scheme. The effective management of Baltic herring and cod stocks requires also settling the resources access allocation scheme.

In seeking an optimal solution to the combined cod-herring allocation problem the possibility for a pay-off between herring and cod was introduced and analysed bearing in mind that the purpose of this analysis is insight, not a concrete practical recommendation. Approach is based on an idea that it is the total value of the landed fish that is allocated among fishing countries rather than individual species quotas.

REFERENCES

Anon. 2004. Report of the Baltic Fisheries Assessment Working Group13–22 April 2004 ICES, Copenhagen. *Advisory Committee on Fishery Management, ICES CM 2004/ACFM:22*

Anon. 2001. Report of the Study Group on the Herring assessment units in the Baltic Sea. ICES Headquarters, 22–25 January 2001. *Advisory Committee on Fisheries Management ICES CM 2001/ACFM:10*

Aps R, Lassen H., Rice J.C., Andrejeva K., Aps J. (in press). Re-allocation of the Baltic herring fishing possibilities. Proceedings of the Estonian Academy of Sciences.

Aps, R. 2004. Management of shared Baltic fishery resources. In: *Management of Shared Fish Stocks*. Payne, A.I.L., O'Brien, C.M. and Rogers, S.I. (Eds.), Oxford, Blackwell; pp.190-201.

Aro, E. 2000. The spatial and temporal distribution patterns of cod (*Gadus morhua callaris* L.) in the Baltic Sea and their dependence on environmental variability – implications for fishery management. Academic dissertation. Finnish Game and Fisheries Research Institute. Helsinki. 75 pp.

Aro, E. 1989. A review of fish migration patterns in the Baltic. *Rapp. P.-v. Reun. Cons int. Explor. Mer*. **190:** 72-96.

Kornilovs G. 2004. Problems of herring assessment and management in the Baltic Sea. In: *Management of Shared Fish Stocks*. Payne, A.I.L., O'Brien, C.M. and Rogers, S.I. (Eds.), Oxford, Blackwell; 2004, pp.42-55.

Nissling A., Westin L. 1997. Salinity requirements for successful spawning of Baltic and Belt cod and the potential for cod stock interactions in the Baltic Sea. Marine Ecology Progress Series 152: 251-261.

Ojaveer E., T. Raid and Ü. Suursaar. 2004. On the assessment and management of local herring stocks in the Baltic Sea. In: *Management of Shared Fish Stocks.* Payne, A.I.L., O'Brien, C.M. and Rogers, S.I. (Eds.), Oxford, Blackwell; pp.240-250.

Ojaveer E. 2002. The role of ICES in the assessment and management of resources in the Baltic Sea. *ICES Marine Science Symposia*, 215: 582-589.

Ojaveer E., Elken J. 1997. On regional subunits in the ecosystem of the Baltic Sea. In: *Proceedengs of the 14th BMB Symposium, August 1995, Pärnu,* pp. 156-169. Estonian Academy Publishers, Tallinn.

Parmanne R., Rechlin O., Sjöstrand B. 1994. Status and future of herring and sprat stocks in the Baltic Sea. Dana **10**: 29-59.

Parmanne R. 1990. Growth, morphological variation and migrations of herring (Clupea harengus L.) in the northern Baltic Sea. *Finnish Fisheries Research,* **10**:1-48.

Sjöstrand (1989). Assessment review: exploited pelagic stocks in the Baltic. *Rapports et Procès-Verbaux des Réunions Conseil International pour l'Exploration de la Mer.* 190: 235-252.

Sparholt H. 1994. Fish species interactions in the Baltic Sea. *Dana* **10**: 131-162.

Sparre, P.J. and R. Willmann, 1992. Software for bio-economic analysis of fisheries. BEAM 4. Analytical bio-economic simulation of space structured multi-species and multi-fleet fisheries. *FAO Computerized Information Series (Fisheries),* No. 3. Vol. 1:186p. Vol. 2:46p.